For engineers who design and manage the power and plant services

Power

JUNE 1958

ONE DOLLAR

A McGRAW-HILL PUBLICATION

Feedwater heaters at CEI built for 4730 psig 105

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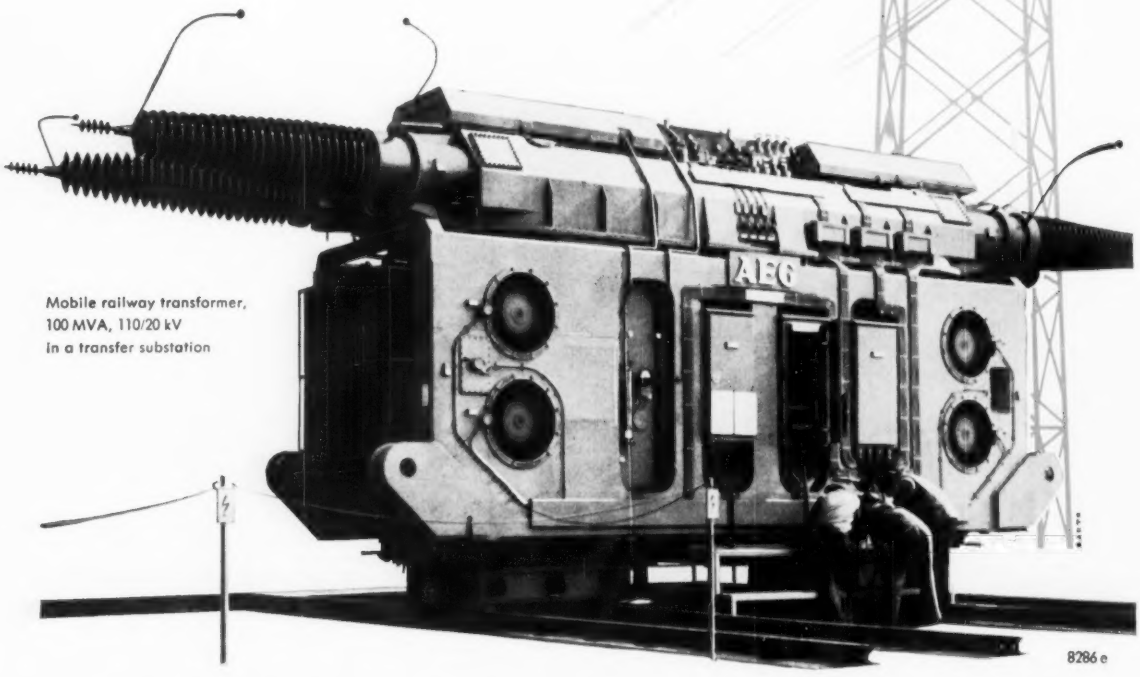
a 32-page special report ▸ 73

AEG

AEG have a long and extensive experience
in the manufacture of transformers
of all sizes and up to the highest voltages.
Three-phase generator transformers
rated for 220.000 V, 200.000 kVA,
with tap changing facilities and line transformers
220.000 kVA, 400.000 V
with a total bank capacity of 660.000 kVA
are amongst the world's largest.
The units are also built
with attached radiators as mobile railway types.



Mobile railway transformer,
100 MVA, 110/20 kV
in a transfer substation

8286 e

ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT

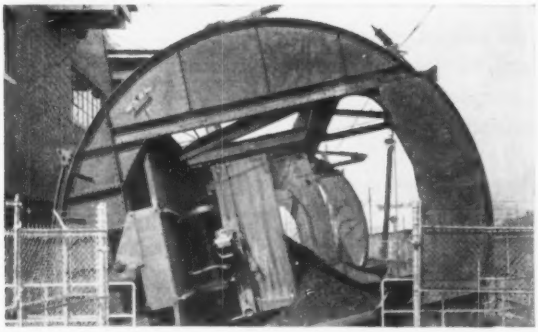
EXPORT DEPARTMENT

BERLIN (WEST) FRANKFURT (MAIN)

LINK-BELT equipment

leads the way to lowest cost-per-ton coal handling

UNLOADING

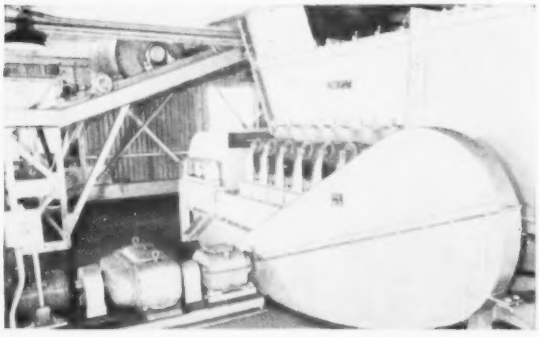


ROTARY DUMPERS provide rapid, economical unloading of all types of open-top cars up to ninety-ton capacity. They empty the load thoroughly, even if coal is moist, fine or frozen.

RECLAIMING

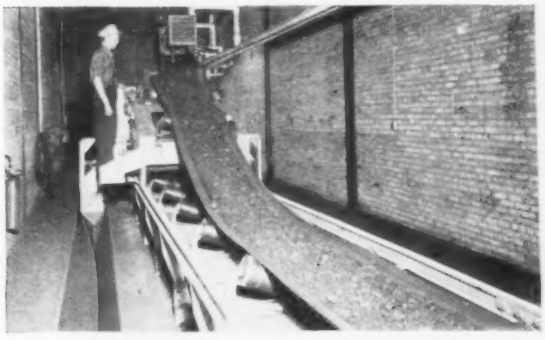
HIGH-CAPACITY RECLAIMING is obtained with independent system of hoppers, feeders and conveyors which assure fast, efficient, economical transfer of coal from storage to bunkers.

FEEDING



FEEDERS move coal from receiving hopper. Line includes belt (above), apron, screw, vibrating and other types. Link-Belt also makes a complete line of mechanical power transmission products.

DISTRIBUTING



BELT CONVEYORS transport large tonnages quickly and at low cost . . . stock out, reclaim, distribute. When distributing coal to bunkers, plow on tripper and bin seal, confine dust.

STORING

STORAGE SYSTEMS for any capacity can be designed, equipped and installed by Link-Belt. At small power plants, Link-Belt elevators, silos and conveyors for reclaiming provide low-cost storage.

IN public utility power plants . . . in commercial, industrial and institutional boiler houses — wherever power, heat or steam for processing is produced by coal, Link-Belt can recommend the right methods and equipment to achieve lowest per-ton handling costs.

Find out how this *one-source* service can improve *your* coal handling procedures. Link-Belt will work with your engineers and consultants from planning through erection of your system . . . or can assume complete responsibility for the entire installation. Contact your nearest Link-Belt office for complete information. Ask for Book 2410.

LINK-BELT

COAL HANDLING EQUIPMENT

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14,880

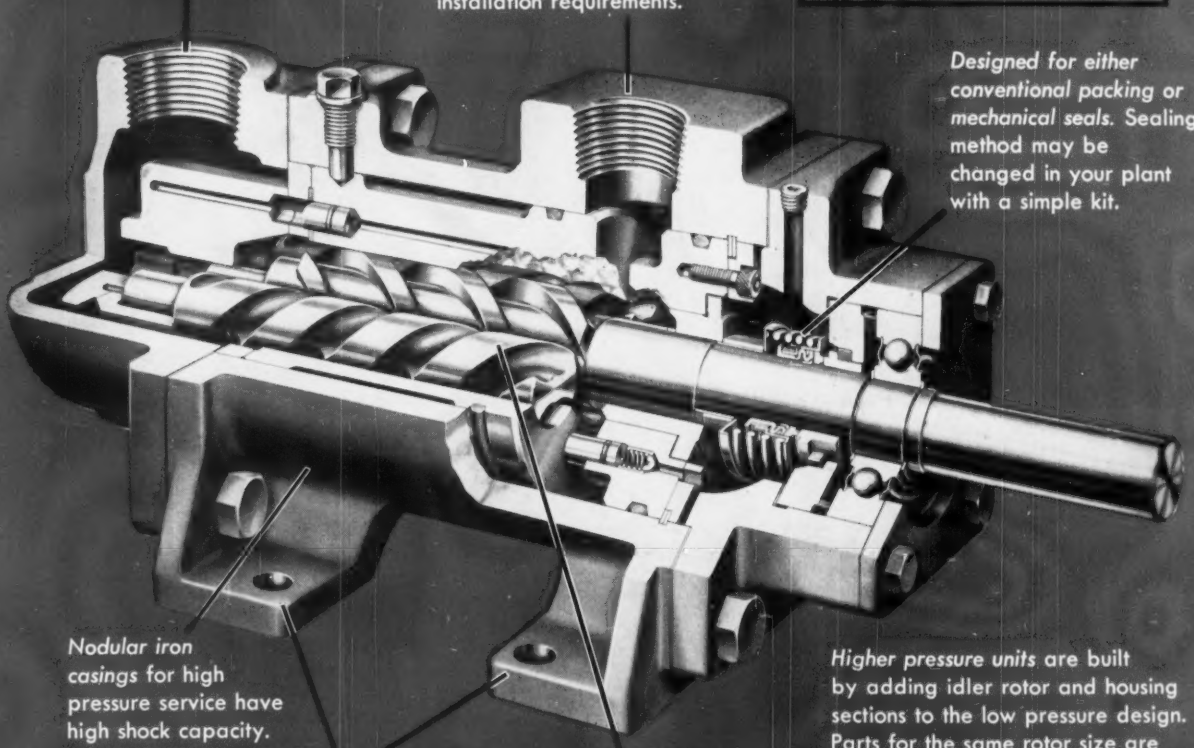
DE LAVAL IMO PUMPS

are now more versatile than ever

De Laval IMO pumps have proved that they do a dependable job over long years of service. The reason is IMO design simplicity. These constant displacement rotary pumps have only three moving parts—smoothly intermeshing rotors that propel the fluid axially in a steady flow without churning, pocketing or pulsation. There are no timing gears, cams, valves, sliding vanes, or reciprocating parts to wear or become noisy. *Quiet*, compact IMO pumps are excellent for direct-connected, high-speed operation.

In addition to these basic pumping advantages, the improved IMO gives you important new benefits shown in the cutaway illustration below.

DE LAVAL IMO PUMPS can also be used as hydraulic motors.



Inlet can be rotated to suit installation arrangement.

Discharge flanges are infinitely varied. You can use the most advantageous piping method to suit installation requirements.

Designed for either conventional packing or mechanical seals. Sealing method may be changed in your plant with a simple kit.

Nodular iron casings for high pressure service have high shock capacity.

Any position mounting is possible without factory modification.

Higher pressure units are built by adding idler rotor and housing sections to the low pressure design. Parts for the same rotor size are interchangeable over the entire pressure range.

Internal parts are designed as a package so that units can be built into your machines.

Bulletin 3001 gives data on improved De Laval IMO pumps. Send for your copy today.

DE LAVAL *IMO Pumps*

DE LAVAL STEAM TURBINE COMPANY

815 Nottingham Way, Trenton 2, New Jersey

DL 418

In Power this month

JUNE 1958 • VOL. 102 • NO. 6 • 76TH YEAR

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How Cincinnati Plant Stops Valve Maintenance Problem

CRANE Valves End Excessive Shutdowns for Repairs

About every four months maintenance men of Sealtest, Central Division, Cincinnati, Ohio, had to replace worn, leaky discs and thread-stripped stems of valves used on the dairy's pasteurizing tanks.

The high cost of down time, labor and parts was only a part of this maintenance problem. Each time the valves had to be repaired, the dairy suffered a drop in production and faced the possible loss of 600 gallons of milk.

Upon recommendation, Crane No. 9 bronze globe valves, with quick-change composition disc, were installed. Today—two and one-half years later—these Crane valves, opened and closed a dozen times a day, have not cost the dairy one cent for repairs, or any loss in production or milk.

Here again is proof that Crane valve economy is never measurable in terms of first cost. You get it in years of maintenance-free service.

That's why more prudent buyers specify Crane valves for every service.

LEARN WHY Crane bronze valves with composition discs are so economical for service on steam, hot or cold water, oil or gas. Write to address below for Circular AD-2222.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

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W K PONDER — Circulation Manager

Power • June 1958 • Vol. 102—No. 6

speaking of Power

While some segments of industry are feeling the effects of a minor business recession, it might seem out of tune with the prevailing concert for POWER to continue speaking about Power to Grow . . . *electrically*—or, for that matter, to devote 32 pages in this issue to a special report on *Electrical Distribution Protection*. Both the PTG series and the latter report deal with the importance of planning and doing *now*, in light of the electrical growth years ahead.

Our belief can be summed up briefly: We're in an excellent climate to look ahead and plan. According to the McGraw-Hill Dept of Economics, America's leading companies are not sitting on their hands waiting for the recession to end. They are looking ahead and making concrete plans now for higher sales and near-capacity rates of operation.

An interesting and accurate perspective, written in 1935 by James H McGraw (founder of the McGraw-Hill Co), could well be applied to the present economic climate:

"The stage is set for a great forward surge in buying. The facts prove unprecedented opportunities lie ahead for the sale of modern equipment. Enlightened industrial leadership must today take hold of the problem of ridding itself of the retarding burden of waste caused by obsolete machinery, methods and processes to the end that profits be increased, that more labor be employed, and that our American standard of living be maintained."

The alert power man will take full advantage of any momentary slowing down in business by planning and acting now for the growth years ahead. And in light of the strong role industrial electrical distribution will continue to play in tomorrow's plants, the special report *Electrical Distribution Protection* is most timely. In brief: You have the time now, tomorrow may be too late.

Lou Lowley

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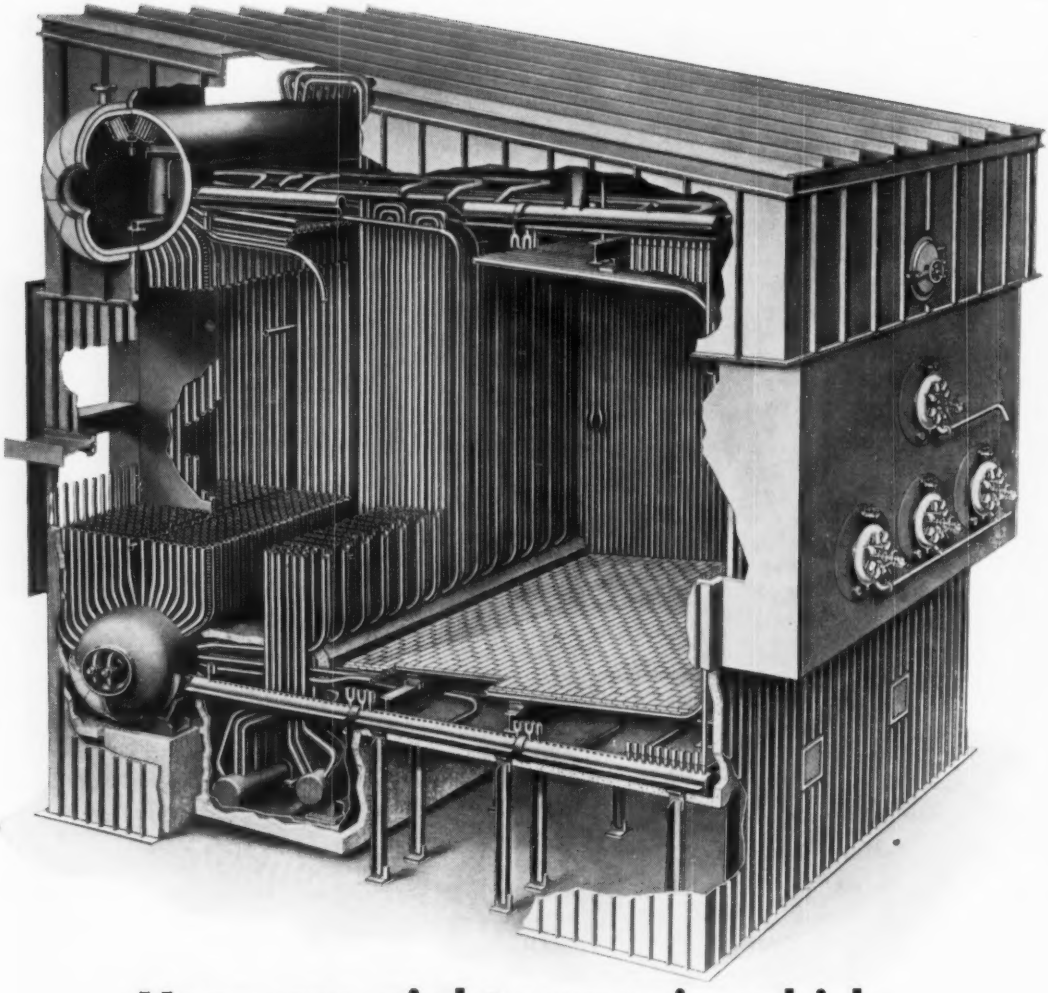

Here are eight ways in which the PFI Boiler can be of benefit to you:

1. It requires a minimum amount of space for a given power output.
2. The pressurized furnace design assures economy by eliminating the induced draft fan and air infiltration. This means savings in cost of fans, fuel, and operating power.
3. Pre-assembly of many of the components of the PFI Boiler is controlled in B&W shops, resulting in a reduction of the time and manpower required for field erection.
4. The PFI is designed to burn oil, gas, or a combination of the two. When it is equipped with a dual-fuel burner, it allows you to take advantage of favorable market conditions.
5. Cyclone Steam Separators ensure adequate water circulation which protects boiler tubes from overheating, even with wide and frequent changes in load. They also give you clean, dry steam at all designed ratings with high boiler water concentrations.
6. The drainable superheater design assures quick, safe start-up and ease of storage.
7. Water-Cooled Burner Throat eliminates troublesome maintenance, costly repairs.
8. All-welded Membrane Wall contributes to high efficiency and reduces insulation requirements.

Announcing New, Economical Power for Industry

New B&W PFI Oil-Gas Burning Unit Provides Maximum Output in Minimum Space

Here's an answer to industry's need for an economical, dependable steam supply. The new B&W Integral-Furnace Boiler produces high-quality, dependable steam economically at all ratings. Aptly named the PFI, the "Power For Industry" Boiler is compact, easy to install, quick to meet rapid and wide load swings. The new boiler gives long, sustained operation, requires little attention and is readily accessible for inspection, cleaning and maintenance.

All responsibility for your complete delivered and erected unit is accepted by one experienced, dependable source which in the past 25 years alone has placed over 4,000 Integral-Furnace Boilers in service. Behind *every* B&W Boiler is nearly a century of leadership in steam generation. A national network of B&W plants and engineering facilities means that the special skills of B&W engineers are always quickly available to you for service and assistance. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

For further information about the B&W PFI Boiler, write for Bulletin G-94.

BABCOCK & WILCOX

B&W

BOILER DIVISION

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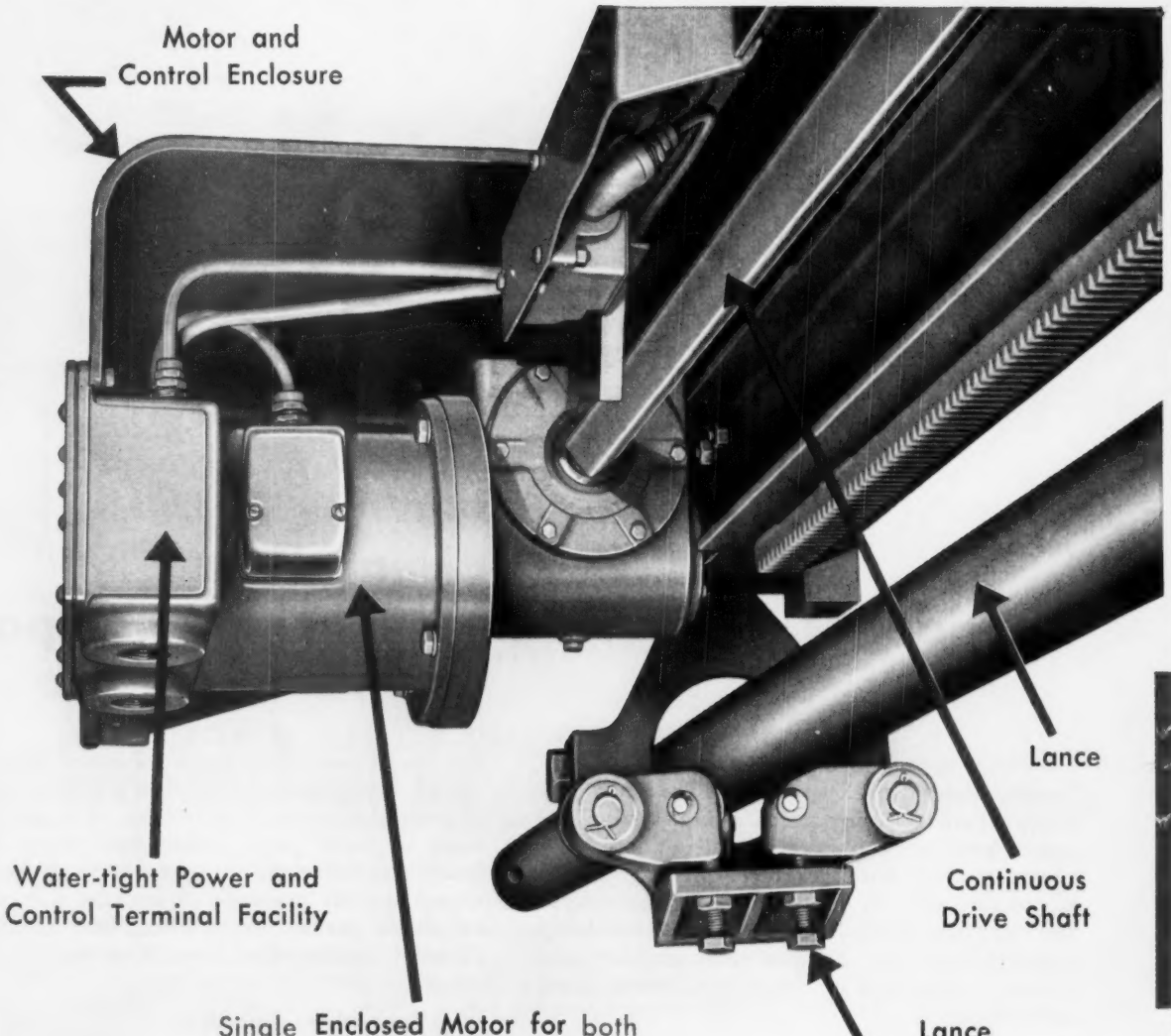
FRONT END



Single Enclosed Motor for both
propulsion and rotation
Motor mounted at boiler end for improved
accessibility and better protection from
physical damage and elements.
(Outboard end motor mounting optional)

Single-Motor DRIVE

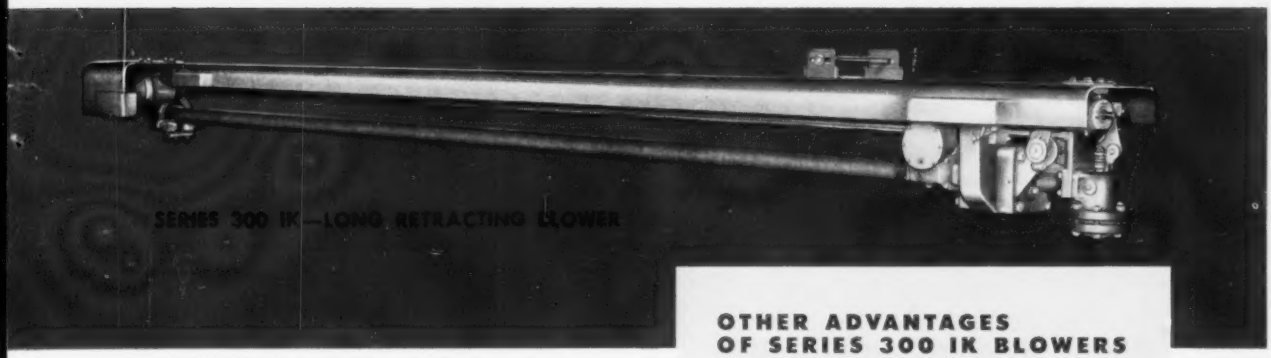
another important feature of

New Diamond

Series 300 IK
LONG RETRACTING BLOWER

As illustrated at the left, only *one motor* is used to simultaneously propel and rotate the lance tube of the new Series 300 IK. The motor is stationary and is mounted at the boiler wall for easier accessibility and greater protection from physical damage and the elements (note the protective enclosure). This front end single-motor drive is simple and dependable. There is only *one* set of motor elements . . . *one* set of control elements . . . and *one* set of power supply facilities to operate and maintain.

Additional important features of the new Series 300 IK are listed in the panel below. Check them and you will understand why this blower is establishing a new standard of efficiency, economy and dependability in cleaning those heating surfaces that require a long retracting blower. For further information about the new Series 300 IK, ask your local Diamond office or write directly to Lancaster for Bulletin 2111U.



OTHER ADVANTAGES OF SERIES 300 IK BLOWERS

- Backbone and Protective Cover
- Compact, Accessible Electric Power and Control Terminal Facilities
- Nozzle-Sweep-Every-Inch Cleaning Pattern
- Improved "Type A" Nozzle
- Positive Gear Carriage Drive
- Poppet Valve with Adjustable Pressure Control
- Positive Mechanically Operated Valve
- Single Point Outboard Suspension
- Oversize Lance (Step-Tapered for Extra Long Travel)
- Auxiliary Carriages for Extra Long Travel
- Designed for Quick, Easy Servicing

No other blower gives you all these advantages.

Diamond **DIAMOND POWER SPECIALTY CORPORATION**

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Windsor, Ontario

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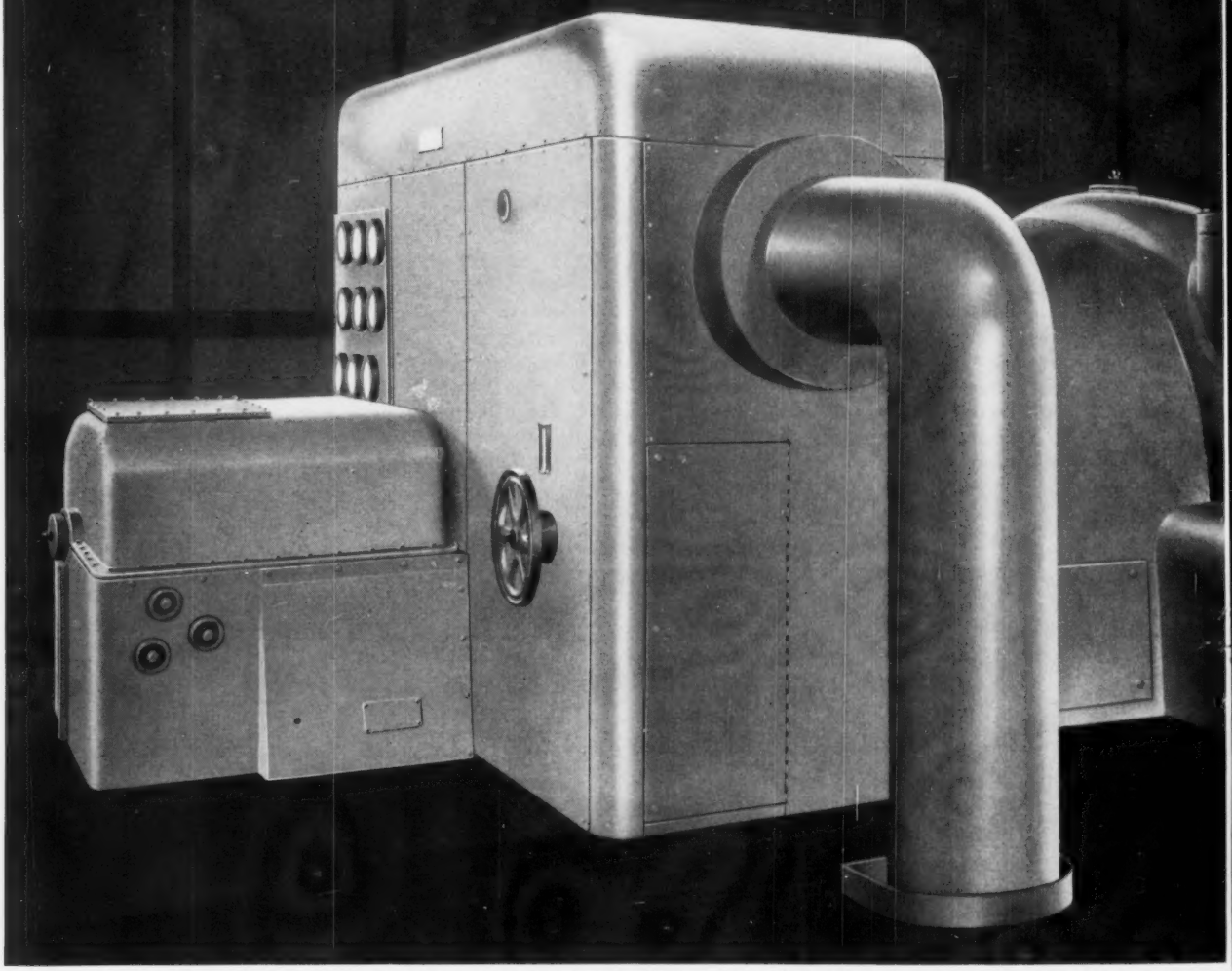
A solid background of TURBINE-GENERATOR



Year after year . . . Elliott turbine-generators are

EXPERIENCE

The excellent operation of this 16,500-kw hydrogen-cooled turbine-generator unit is the result of Elliott Company's background of 50 years experience in designing, and building turbine-generator units. The steady march in size ratings is accomplished by a step-by-step introduction of proven components added to each larger size.

Elliott is currently building a 33,000-kw unit and has the facilities, experienced engineers, and craftsmen, to produce size ratings to 44,000 kw. For complete engineering data, call your nearby Elliott district office or write Elliott Company, Steam Turbine Department, Jeannette, Pa.

ELLIOTT Company

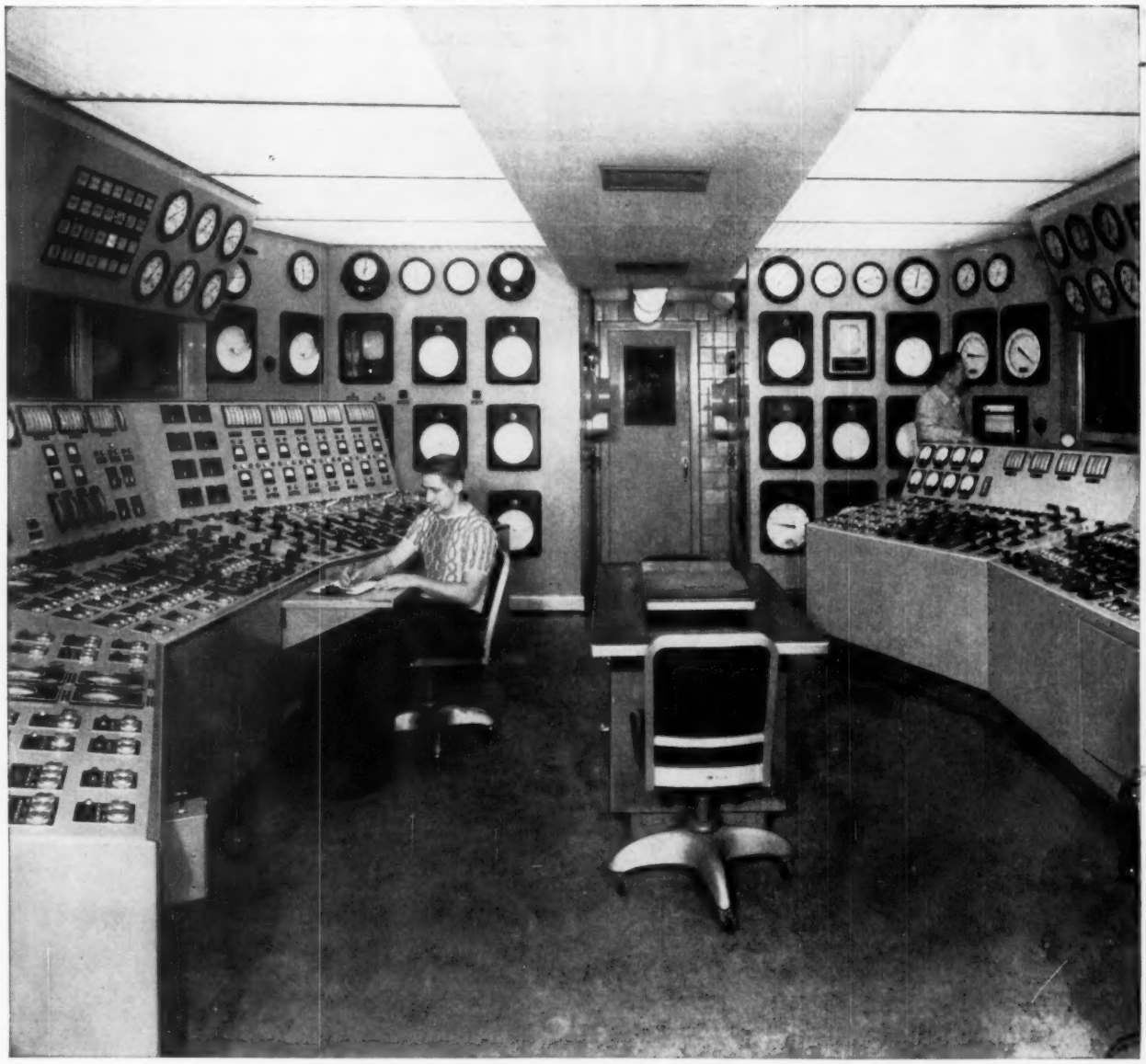
HS-4

In this turbine-generator aisle, Elliott has the large machine tool equipment and handling facilities for manufacturing. Under construction is a 33,000-kw unit—designed and built to meet the exact requirements of the user.

1957...33,000 KW

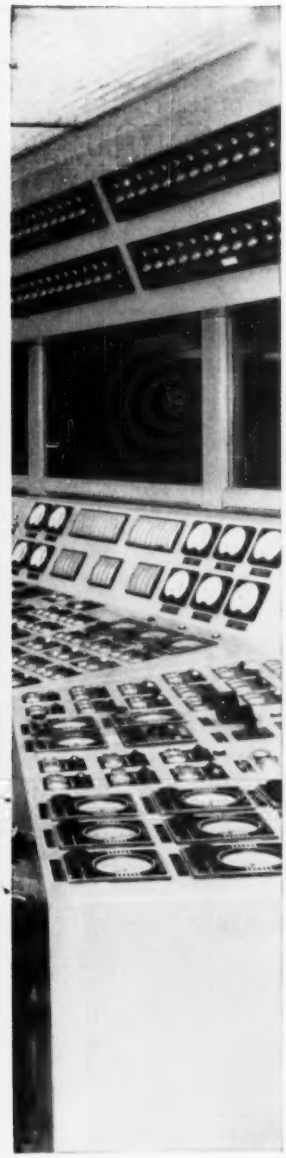
getting Bigger and Bigger

14 out of the 15



The steam control room for units 3 and 4 of the Eastlake Plant of The Cleveland Electric Illuminating Company. Eastlake uses Bailey Meters and Bailey Controls for Combustion, Feed Water and Steam Temperature. The FPC reported a 1955 heat rate at Eastlake of 9,336 Btu per kwhr, making it the seventh most efficient plant in the United States.

"most efficient*" plants use Bailey Meters and Controls



How's that for a vote of confidence! In the electric power industry, quality and dependability of equipment are paramount and 14 out of the top 15 power stations on the FPC's 1955 list chose Bailey Meters and Controls. Nine of these 15 chose Bailey equipment exclusively!

For breadth of product line, depth of experience, size and quality of field service organization, no one offers more to the power industry than Bailey. And the time to contact Bailey is during the early planning stage, when our recommendations can save time, trouble and money. Our engineers are at your service.

* 15 MOST EFFICIENT PLANTS

1955 Heat Rates Reported by FPC

	Btu/kwhr	Meters	Comb. Cont.	Feed Water Cont.	Steam Temp. Cont.
1. Kyger Creek (Ohio Valley Electric Corp.) . . .	9,110	B		B	B
2. Clifty Creek (Indiana-Kentucky Electric Corp.) .	9,143	B	B	B	B
3. Kanawha River (Appalachian Electric Power). .	9,151	B	B	B	B
4. St. Clair (Detroit Edison Co.)	9,220	B	B	B	B
5. Muskingum River (Ohio Power Co.).	9,234	B	B	B	B
6. Tanners Creek (Indiana & Michigan Electric Co.) .	9,273	B	B	B	B
7. Eastlake (Cleveland Electric Illuminating Co.) . .	9,336	B	B	B	B
8. Philip Sporn (Ohio Power Co.).	9,341	B	B	B	B
9. Shawville (Pennsylvania Electric Co.)	9,368	B			B
10. Albany (Niagara Mohawk Power Corp.) . . .	9,373				
11. El Segundo (Southern California Edison Co.) . .	9,417	B	B	B	B
12. Oak Creek (Wisconsin Electric Power Co.) . . .	9,480	B	B	B	B
13. Kearney "B" (Public Service Electric & Gas Co.).	9,511	B		B	B
14. Dunkirk (Niagara Mohawk Power Corp.) . . .	9,523	B	B	B	
15. Cromby (Philadelphia Electric Co.)	9,540	B		B	B

B — Bailey installation

AI30-2

Instruments and controls for power and process

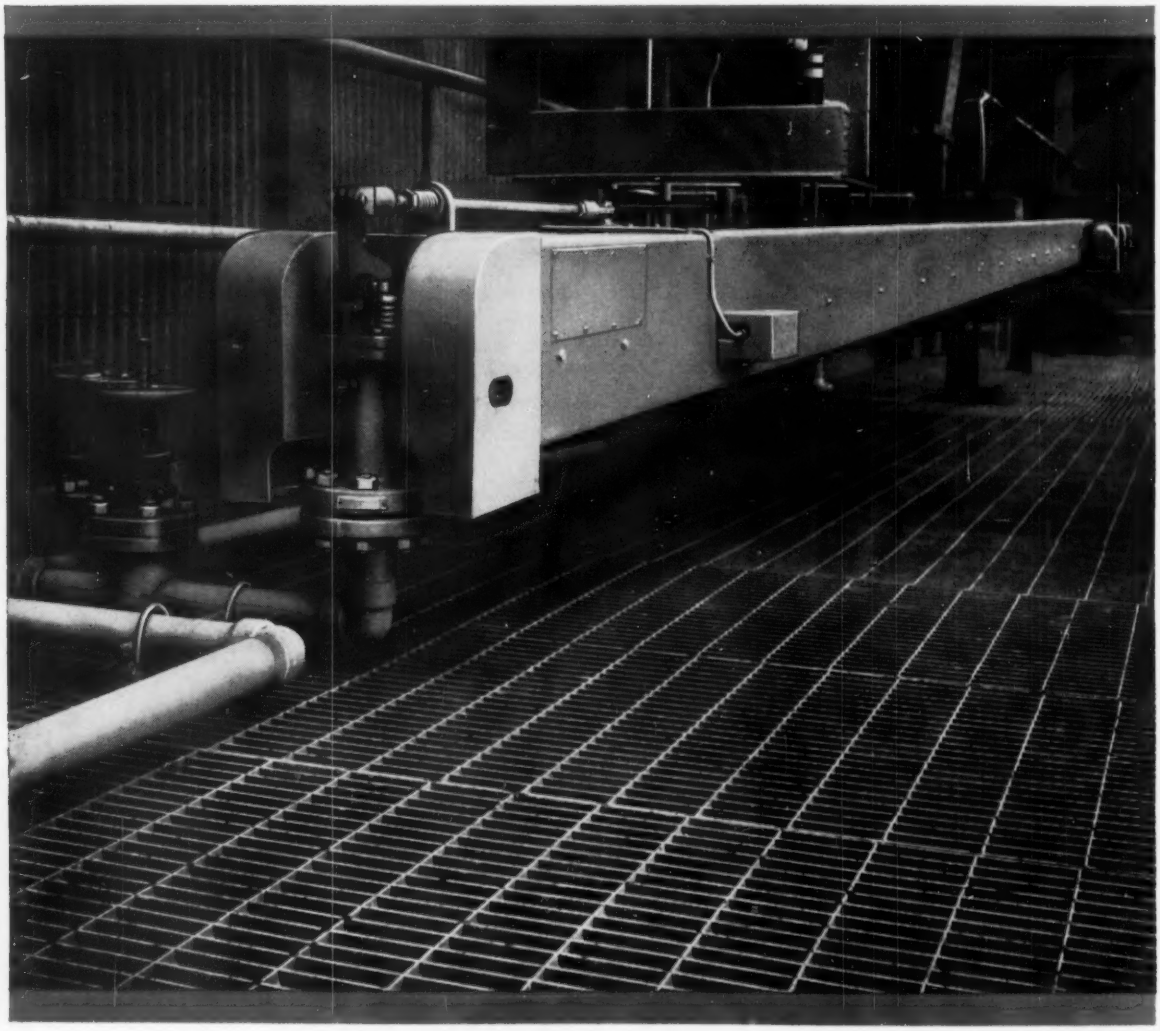
BAILEY METER COMPANY

1036 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

Vulcan T-30 long cover record at Meramec Station!



This Vulcan T-30 long retractable soot blower has been in operation on Unit 1 at Meramec Station since May, 1956. Fuel for the Combustion Engineering boiler is pulverized coal. Burners are arranged for tangential firing and can be tilted for superheat control.

C-3447

retracts distance

A Vulcan T-30 long retractable soot blower is reaching more than 35 feet between two banks of the pendent secondary superheater on Boiler No. 1 in Meramec Station of Union Electric Company of Missouri. This Vulcan T-30 requires only one outboard hanger to support the extra-rugged framework. Lance travel and rotation are non-synchronized through two driving motors to produce a multi-helix cleaning path to cover different areas of the tube bank while extending and retracting.

Performance of this Vulcan T-30, which is located at the furnace exit where temperatures average 1910 degrees F., led to the selection of Vulcan T-30 blowers with 36-foot travel, RW-3E wall deslaggers and E-4-E rotaries—all under automatic-sequential control—for Meramec's new Unit 3, a Foster Wheeler boiler with separate furnaces, rated at 1,850,000 pounds per hour at 2150 psig and 1010 degrees F., with reheat to 1010 degrees F.

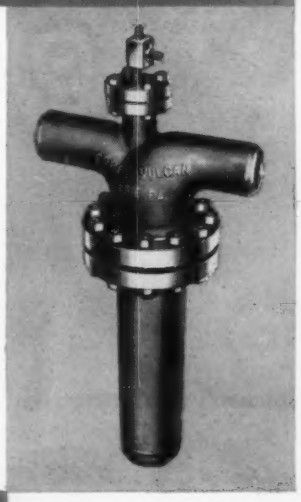
Whether your boiler is large or small, power or process, modern Vulcan soot blowers will help keep it operating at peak efficiency. Your Copes-Vulcan representative has the ideas, information and experience to help you choose the system best suited to your needs.

COPES VULCAN

BLAW-KNOX

COPES-VULCAN DIVISION
BLAW-KNOX COMPANY
ERIE 4, PENNSYLVANIA

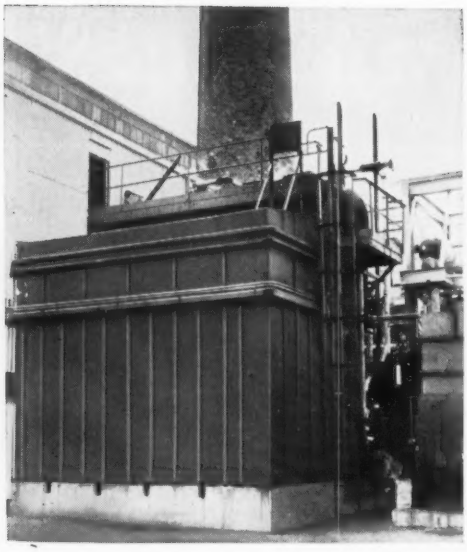
C-V NEWS NOTES



Copes-Vulcan Steam-Assist Desuperheater meets all specifications for conventional steam-atomizing type, yet normally uses assisting steam only on light loads where control is most difficult. Furnished with carburetor body as shown, or for in-line installation. Simple mechanical-atomizing types are also available. Bulletin 1024-A.

Unlimited pressures and sizes up to 16-inch, plus simplified design, are features of the new Copes-Vulcan Types CV-D and CV-P valves. Either diaphragm or piston types are available for pressure, temperature or liquid level control. Bulletin 1027.

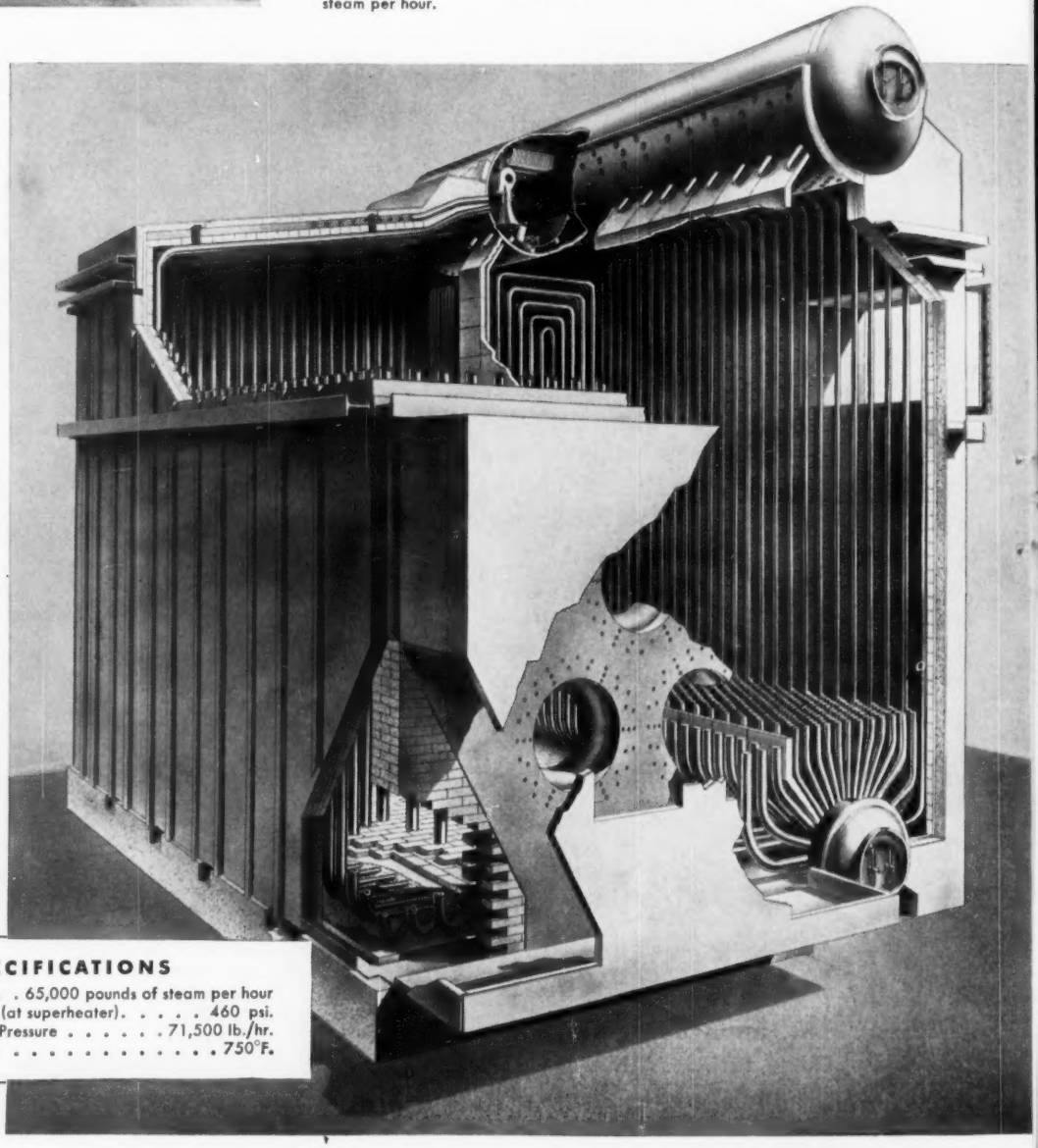
Bulletin 1030 illustrates and describes the Vulcan T-30 long retractable soot blower, now successfully operating in temperatures up to 2150 degrees F. (radiant). Your Copes-Vulcan representative can give you a copy, or write direct to the factory.



Foster Wheeler "SC" Standard at Socony Mobil Oil Company

Republic

The "SC" Series Standard Steam Generator is the latest development by Foster Wheeler Corporation toward the reduction of steam costs for industrial plants through engineering and standardization. This unit installed at the Brooklyn Refinery of Socony Mobil Oil Company, is built with Republic ELECTRUNITE Boiler Tubing. It operates continuously at its guaranteed 2-hour peak load capacity of 71,500 lbs. of steam per hour.



SPECIFICATIONS

Capacity. . . . . 65,000 pounds of steam per hour
Operating Pressure (at superheater). . . . . 460 psi.
Maximum Working Pressure . . . . . 71,500 lb./hr.
Steam Temperature . . . . . 750°F.

Boiler delivers 71,500 lbs./hr. in round-the-clock operation Brooklyn Refinery...designed and built with

ELECTRUNITE Boiler Tubing

Republic ELECTRUNITE® Boiler Tubing offers designers, erectors, and end-users built-in quality that can be measured by dependable, economical day-in, day-out service.

The "SC" Series Standard Steam Generator, designed and developed by Foster Wheeler Corporation, is providing round-the-clock power and service economies at the Brooklyn Refinery of the Socony Mobil Oil Company. This unit uses Republic ELECTRUNITE Boiler Tubes.

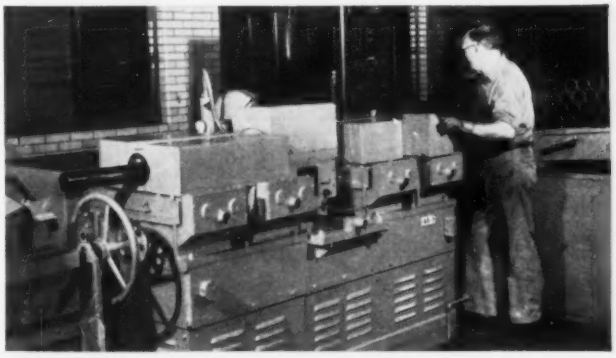
It has been found entirely feasible to operate this unit *continuously* at its guaranteed 2-hour peak load capacity of 71,500 lb. of steam per hour—6,500 lb./hr. in excess of rated capacity.

Designed for oil firing, with burners arranged for alternate burning of refinery gas, this two-drum water-tube boiler delivers 460 psi., 750°F. steam at the superheater outlet. Fitted with turbine-driven forced and induced draft fans, it is of balanced draft design, with highly efficient firing arrangement and over 19-feet of horizontal flame travel.

Low installation costs are possible because ELECTRUNITE is ductile, truly concentric, with exacting uniform wall thickness. It goes in fast, goes in easy. Quality is built-in. ELECTRUNITE is made of highest quality flat-rolled open-hearth steel produced in Republic's own mills to Republic's rigid specifications . . . quality controlled from ore to finished product.

Each length of Republic ELECTRUNITE Boiler Tubing is hydrostatically or electronically tested to conform with applicable ASTM specifications, the ASME Boiler and Pressure Vessel Code, as well as local, state, and boiler insurance requirements. Republic ELECTRUNITE is approved on an equal basis with tubes made by other processes up to 850°F. It is available for pressures over 2,000 psi, in various sizes and wall thicknesses.

To learn how Republic ELECTRUNITE can help you solve your boiler, condenser, heat exchanger tubing problems, call your Republic representative, or write direct.



FARROWTEST® is more than a quality control test. It detects and rejects defects of critical size. This quality protection is your proved production safeguard. Republic offers you the additional quality protection of exclusive FARROWTEST, as an alternate to other, less positive tests. It can be applied to your next order of Republic ELECTRUNITE Boiler Tubing.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. PO-5500
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send the following literature:

- ☐ Booklet—ELECTRUNITE Boiler Tubes
- ☐ Brochure—ELECTRUNITE Heat Exchanger Tubing
- ☐ Carbon Steel
- ☐ Stainless Steel
- ☐ FARROWTEST information
- ☐ Wall Chart on care and maintenance of boiler tubes

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

LARGEST SINGLE-FURNACE STEAM GENERATOR

WILL DELIVER 2,310,

for Unit No. 4 at Union

New 300,000 kw generating unit will increase station capacity to 860,000 kw

WITH Unit No. 3 still in the final stages of construction, Union Electric Company has already contracted for the addition of Unit No. 4 to the fast-growing Meramec Station. This new generating unit, scheduled for completion in 1961, will be the largest on the Union Electric system, adding 300,000 kw and bringing Meramec Station's total capacity to 860,000 kw.

Steam for the new turbo-generator will be supplied by a Foster Wheeler reheat steam generator with a maximum continuous rating of 2,310,000 pounds per hour — the largest FW single-furnace unit ever built! Pressure at the superheater outlet will be 2200 psig and primary and reheat steam will have a final total temperature of 1010F/1010F, with a reheat steam flow of 1,790,000 lb/hr.

The unit is designed for balanced draft operation, firing pulverized coal. Three Foster Wheeler D-9 Ball Mill Pulverizers will prepare fuel for the 18 FW Intervane Burners.

The new 2,310,000 lb/hr steam generator will take its place beside another FW unit — the 1,850,000 lb/hr twin furnace, dual circulation reheat steam generator for 275,000 kw Unit No. 3 at Meramec Station.

The proved dependability and long-range economy of Foster Wheeler steam generators are backed by more than 50 years of experience in pioneering power plant equipment. We will be pleased to quote on your requirements.

Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N. Y.

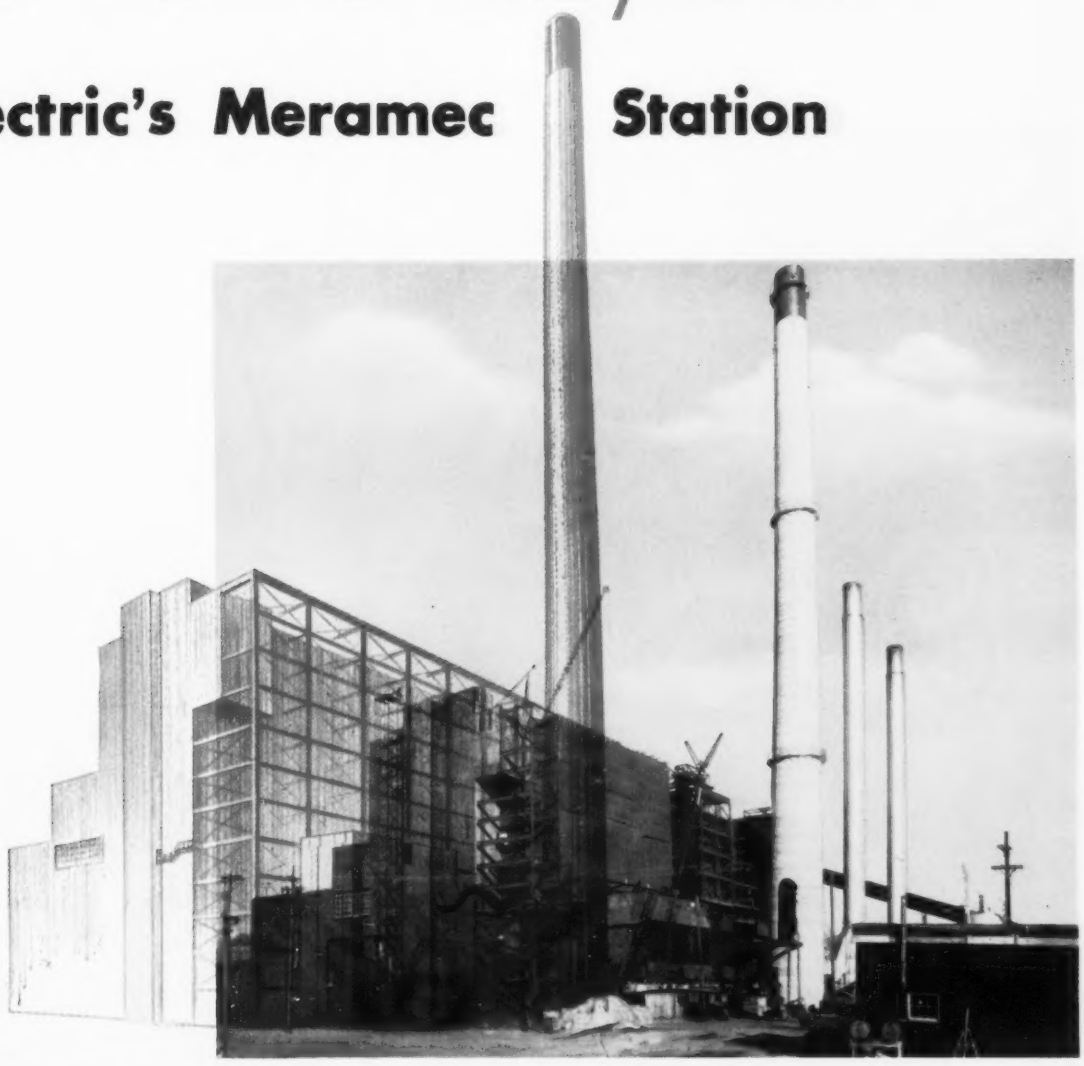
STEAM GENERATORS • SURFACE CONDENSERS
FEEDWATER HEATERS • HEAT EXCHANGERS • ECONOMIZERS
SUPERHEATERS • BALL PULVERIZERS • COOLING TOWERS

FOSTER

EVER BUILT BY FOSTER WHEELER

000 lb/hr

Electric's Meramec Station



The photo above shows Union Electric's Meramec Station, with Unit No. 3 under construction. This 275,000 kw unit, supplied by a Foster Wheeler twin furnace, dual circulation reheat steam generator of 1,850,000 lb/hr capacity, is scheduled to go on the line this summer. The artist's sketch, in color, shows the location of 300,000 kw Unit No. 4, which, when completed in 1961, will bring total station capacity to 860,000 kw. The new unit will be served by the largest single-furnace steam generator ever built by Foster Wheeler — with a maximum continuous rating of 2,310,000 lb/hr, 2200 psig, 1010F/1010F.

WHEELER

NEW YORK • LONDON • PARIS
ST. CATHARINES, ONT.

In Iron Body Wedge Gate Valves,
Outside Screw and Yoke Design,

Walworth offers you these 8 outstanding advantages!

STRONGER CONNECTIONS. T-head disc-to-stem connection on OS&Y types permits wedge to properly seat itself.

TIGHTER SEAL. Solid web type disc on OS&Y valves provides tight closure, greater strength and longer service.

REDUCED TURBULENCE. Fluid action is minimized due to this straight-flow port design.

FEWER OBSTRUCTIONS. Seat rings of bottom-seated types are screwed into body to prevent gum and grit accumulations.

Walworth Subsidiaries: ALLOY STEEL PRODUCTS CO. · CONOFLOW CORPORATION · GROVE VALVE AND REGULATOR CO.

SURE-GRIP HANDWHEEL. Fluted design assures a sure grip, even with greasy gloves.

HIGH CORROSION RESISTANCE. Brass liner protects glands from deterioration and scoring.

EASIER REPACKING. Hinged gland eye-bolts on OS&Y valves permit fast maintenance under full pressure.

LESS DAMAGE. Bronze back-seat bushing in bonnet of OS&Y valves prevents scoring, guides stem accurately.

Walworth Iron Body Gate Valves are available with screwed or flanged ends, in sizes and types for every purpose.
For full information see your Walworth Distributor or write:
Walworth Company, 750 Third Avenue, New York 17, N. Y.

*WALWORTH is a registered trademark of WALWORTH COMPANY

WALWORTH*

VALVES . . . PIPE FITTINGS

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

M & H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING AND WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.

STOCK

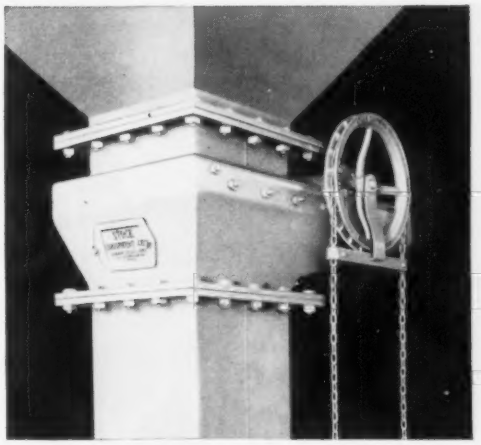
Dramatic "upside down" test tells

The inside story on the S-E-CO Coal Valve...

The simple test illustrated here proves graphically that the S-E-CO Coal Valve works under almost any kind of condition—even while it's standing on its head.

One reason for the superiority of the S-E-CO Valve is the exclusive self-cleaning design of the racks and pinions. Double pinions on either side of the gate project *through* the ladder racks, because the root portions of the racks have been eliminated. There is no place for coal to build up and cause jamming or cocking. This self-cleaning design helps the S-E-CO Valve operate smoothly and easily, even after long periods of infrequent use.

There are many other features that help to make the S-E-CO Coal Valve your best valve buy. Just one word of caution. Be sure to install *your* S-E-CO Valve right side up. It works even better that way.



BUILDING THE STANDING COLUMN

Valve is inverted and filled with coal. In this position racks and pinions are exposed. Normally an extra deep U-shaped gate protects them from contamination by coal particles.

PACKING THE COAL AGAINST PINIONS

2 x 4 is used to spread coal through valve and pack it against pinions (see opposite page). Don't forget, the valve gate must force its way through the coal that already fills the valve.

EVEN UPSIDE DOWN... IT CLOSES!

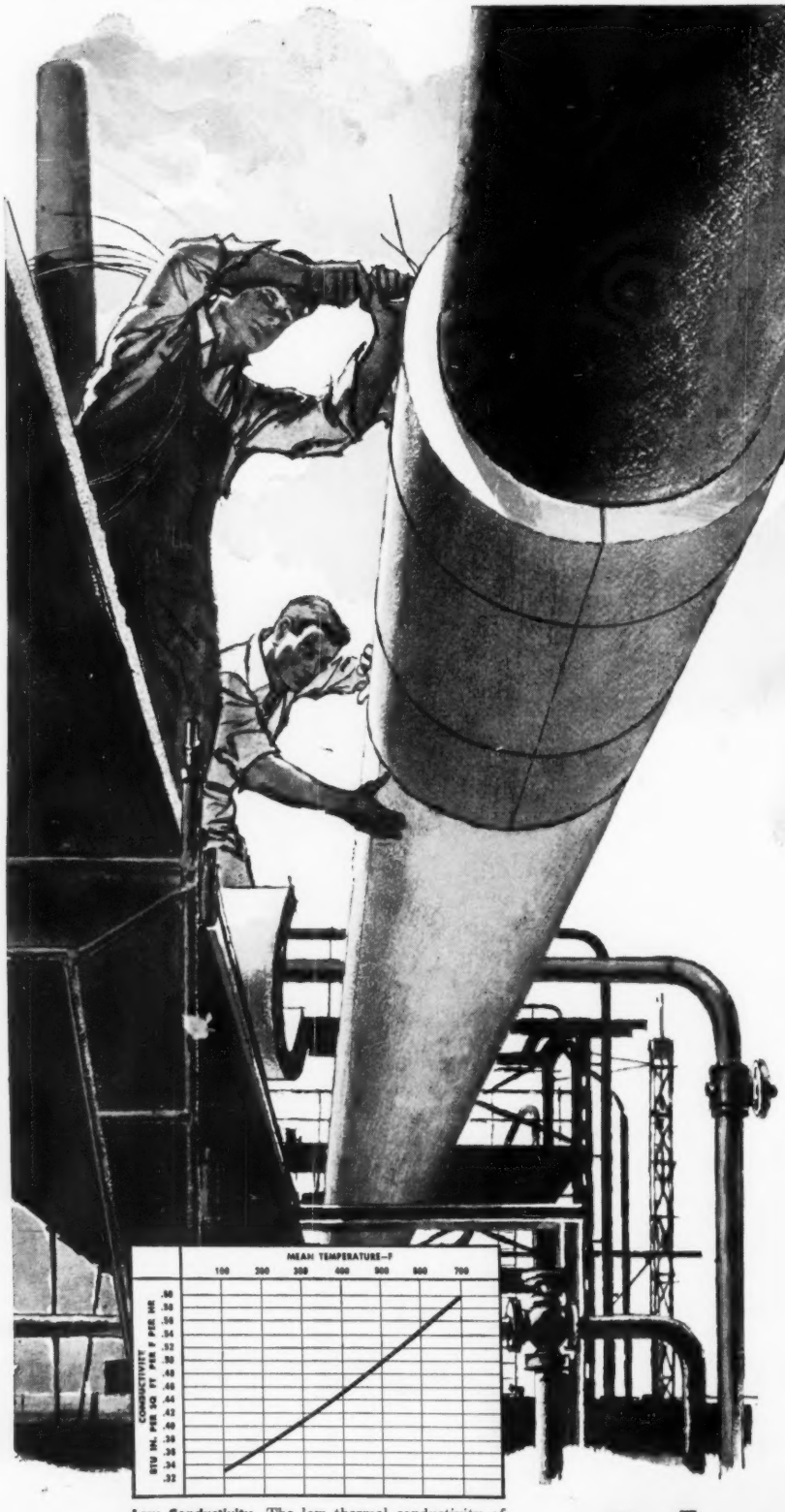
Here's proof that S-E-CO racks and pinions are *truly* self-cleaning. Valve gate closes, completely. And it opens again, all the way. If it works under these conditions, it will work even better for you.

Get the rest of the inside story on the S-E-CO Coal Valve. Send now for Bulletin 97.

Equipment Company

745-P HANNA BLDG. • CLEVELAND 15, OHIO

In developing THERMOBESTOS Insulation for J-M at



Low Conductivity. The low thermal conductivity of Thermobestos is best demonstrated in actual service where it makes possible accurate, uniform temperature control, helps reduce fuel costs and contributes materially to operating efficiency.

Not damaged by water. Thermobestos has the moisture resistance outdoor service demands. Soak it in water for one day or 365—and you can still walk on it without damage. Dry it out and Thermobestos is as good as new, with conductivity and structural strength unimpaired.

Johns-Manville

rugged industrial service . . . indoors and out

research scientists didn't stop top insulating effectiveness...

They added the three physical properties you most wanted— HIGH STRENGTH—LIGHT WEIGHT —MOISTURE RESISTANCE!

THERMOBESTOS® offers the lowest *k* factor of all insulations in general use throughout the power-generation and process industries. For maximum heat control to 1200F it just can't be beat.

Yet top insulating effectiveness is only one reason why Thermobestos is being specified by more and more engineers for power plants, steam-generating stations, and wherever hot piping and equipment must be insulated. For Thermobestos also offers a threefold bonus . . .

. . . Three outstanding physical properties

Thermobestos is 1) strong and rigid. Its hard composition resists crushing and easily withstands unusual service abuse. Yet it is 2) lightweight for easy handling and fast application. And it is 3) highly moisture resistant, remains undamaged even by prolonged wetting.

Quickly, easily applied

Thermobestos is made from hydrous calcium silicate . . . molded to size for proper fit. Its high strength makes it particularly adaptable for time-saving shop prefabrication of fittings and bends.

Furnished in large sections, Thermobestos is easy to apply. It reduces the number of joints In pipe insulation form, it comes in a complete selection of sizes up to 30″ O. D. Also available in 6″ x 36″ and 12″ x 36″ blocks in a full range of thicknesses.

For further information write for your free copy of the 12-page Thermobestos booklet, IN-169A. Address Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

INSULATIONS FOR LASTING THERMAL EFFICIENCY
MATERIALS • ENGINEERING • APPLICATION

JOHNS-MANVILLE JM PRODUCTS

it's **boiler check-up** time!

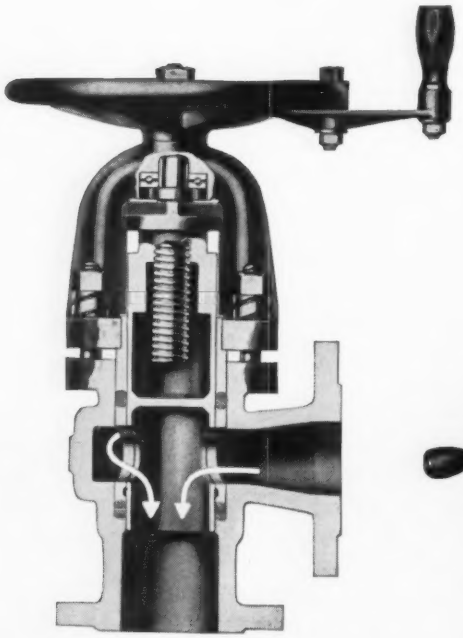
HOW ARE YOUR BLOW-OFF VALVES?

Are they drop-tight? Rugged and dependable? Easy to maintain?

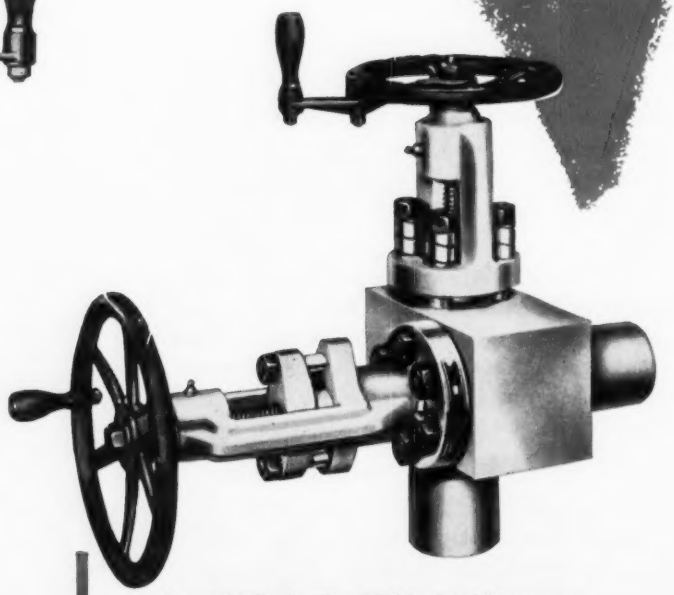
Just as important, do they have all the advantages and up-to-date improvements in materials and design of new YARWAY Blow-Off Valves?

Old YARWAY Blow-Off Valves also can be overhauled and modernized, because all YARWAY improvements are *interchangeable* with parts on earlier models.

Write today for YARWAY Blow-Off Valve CHECK SHEET—also new YARWAY Blow-Off Valve Catalog B-426 (pressures to 400 psi) or B-434 (pressures to 2500 psi).



Yarway Seatless valve for low and medium pressures. Features balanced nitralloy plunger that seals line drop tight—yet permits free, unobstructed flow in blow-down. **Used in over 15,000 boiler plants.**



Yarway Unit Tandem Blow-Off Valve for higher pressures. Combines Yarway Seatless Valve and Yarway Hard-Seat Valve, or two Yarway Hard-Seat Valves, in a one-piece forged steel body. For years—the choice of 4 out of 5 high pressure power plants.

YARWAY steam

✓ WHAT ABOUT WATER COLUMNS AND GAGES?

Are they in good working order? Are they up-to-date?

If your boiler pressures are over 900 psi, have you considered the advantages of the new YARWAY COLOR-PORT Gage? It offers brilliant two-color (red and green) readings, greatly reduced maintenance, increased availability and longer service life.

Write for full details in Bulletin WG-1814

✓ HOW ABOUT ADDING NEW REMOTE LEVEL INDICATORS?

Remote readings of boiler water level at any spot in the plant are a recognized convenience —and easy with "Wide Vision" YARWAY Remote Liquid Level Indicators.

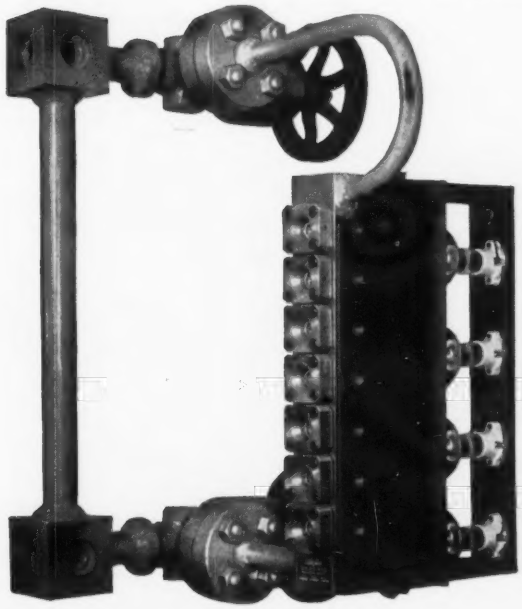
Because the indicating mechanism is operated by the boiler water itself, response is always instant, readings always accurate.

YARWAY Hi-Lo Graph Recorder not only gives remote indication but also a 24-hour recording of water levels.

YARWAY Remote Indicators and Recorders can also be supplemented with Remote Hi-Lo Alarm Signals—light or horn.

Write for Catalog WG-1824.

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES



Side view of new Yarway Color-Port Water Level Gage with illuminator, circulating tie-bar and Welbond gage valves. Water space shows green in the gage; steam space shows red.

Yarway Remote Liquid Level Indicator with "wide vision" face. Manometric type with automatic temperature compensation where required. Over 10,000 used throughout industry.

plant equipment

REQUIRED: Economical Steam Generation
PURCHASED: BROS Boilers and Stokers

Some recent Bros Boiler and Stoker Installations

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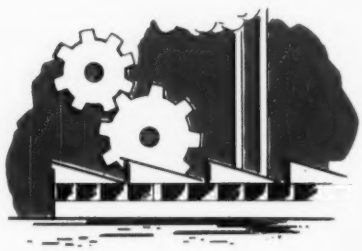

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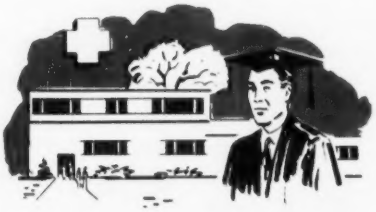

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BEN FRANKLIN REFINING CO.
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Worland, Wyoming
PHILLIPS PETROLEUM CO.
Grants, New Mexico
MID-AMERICAN REFINING CO.
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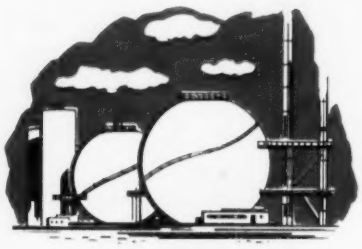

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RICHLAND CO-OP CREAMERIES CORP.
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LAND O' LAKES CREAMERIES, INC.
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DAIRY MAID CO-OP CREAMERY
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MORTON FOODS
Dallas, Texas
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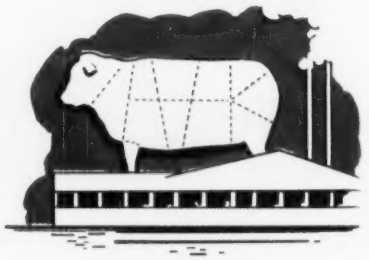
Omaha, Nebraska



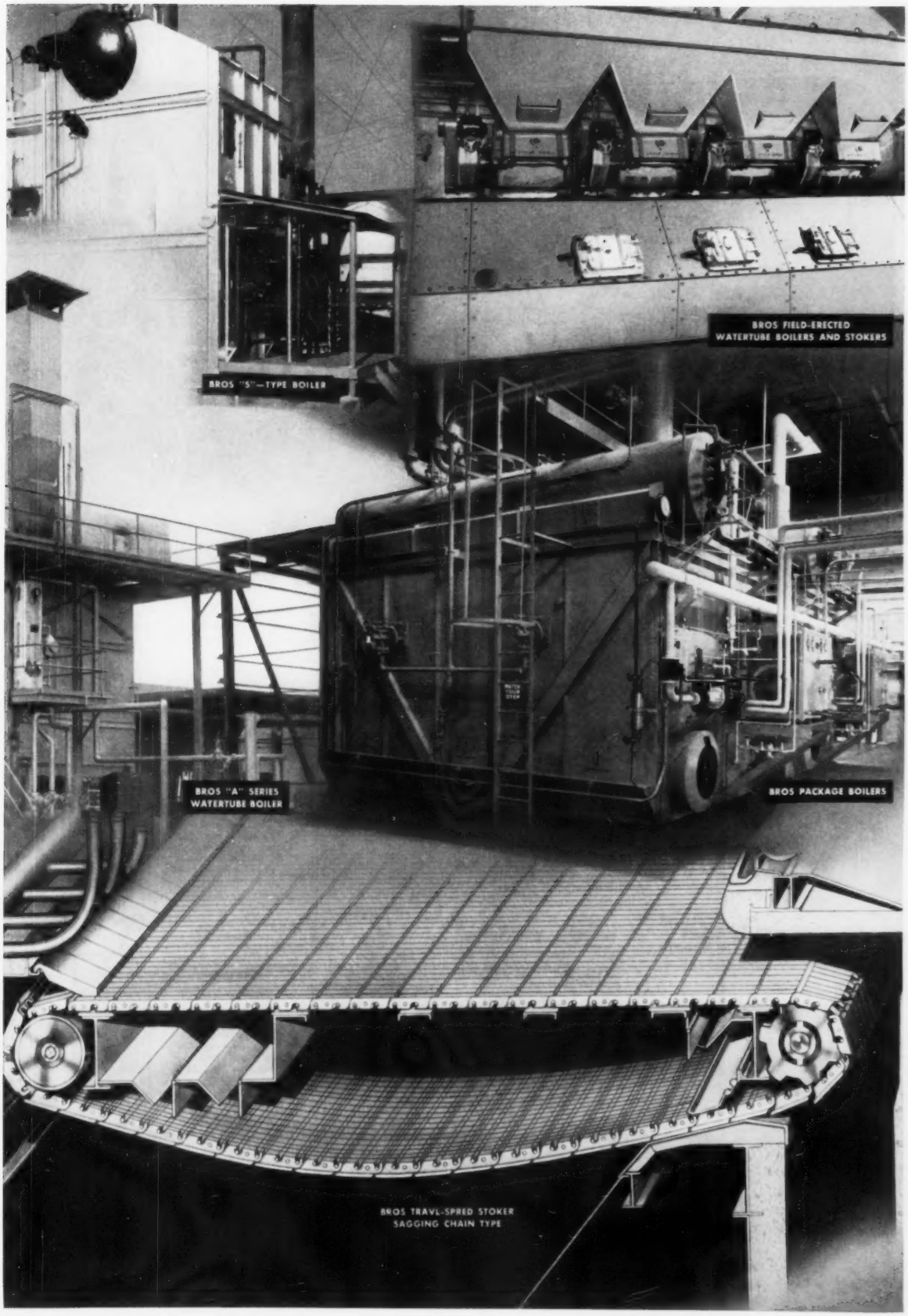
For descriptive literature on high or low pressure
BROS *Steam Generation Equipment, write:*

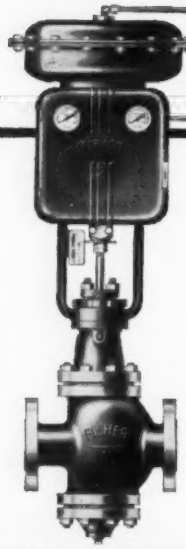
BROS

BROS *Incorporated* POWER DIVISION

(formerly Wm. Bros Boiler & Mfg. Co.)

1057 TENTH AVE. S. E. • MINNEAPOLIS 14, MINNESOTA


BROS FIELD-ERECTED
WATERTUBE BOILERS AND STOKERS
BROS "S"—TYPE BOILER
BROS "A" SERIES
WATERTUBE BOILER
BROS PACKAGE BOILERS
BROS TRAVL-SPRED STOKER
SAGGING CHAIN TYPE



Any of the Wizard controllers can be yoke mounted on a diaphragm control valve to make a compact pilot operated pressure regulator as shown above. All Wizards are normally supplied with an operating medium air set which filters and reduces supply pressure of 25 to 250 psi to constant pressure of 20 psi for 3 to 15 psi, or 35 psi for 6 to 30 psi operation.

SURFACE MOUNTING

The Wizard can be mounted on the surface of a wall or any stable surface. A special mounting bracket is provided and any type of screw or bolt suitable for the mounting surface may be used.

FLUSH MOUNTING

By turning the bracket around that is provided for surface mounting, any Wizard can be mounted flush to a panel.

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

For closer control in today's more complex processing industries

FISHER®

WIZARD II PRESSURE CONTROLLER

For over a quarter century, the name "Wizard" has become a byword as the pressure controller that is accurate, dependable and simple to operate in all types of industry.

Now, the WIZARD II takes over to meet the demands of modern, complex control systems requiring closer control. The WIZARD II retains all of the basic simplicity, accuracy and dependability of the Wizard 4100U, plus a number of new components. The WIZARD II is in a waterproof aluminum die-cast case and cover with ¼" tapped vent for gas service. With the addition of a few parts, the basic proportional controller can be converted to: (1) two-position action or "Snap Action", (2) pressure transmitter, (3) controller with remote set adjustment, (4) proportional plus reset response. The WIZARD II can be changed from direct to reverse action or vice versa without additional parts.

The superior subassembly construction stresses simplicity and compactness. Each subassembly is assembled and calibrated prior to mounting in the case. All Series 4150 Wizards can be supplied for remote set adjustment for changing the pressure setting from a location away from the Wizard controller.

Careful and exhaustive tests have conclusively proved that the WIZARD II measures up to the rigid Fisher standards.

A completely descriptive and illustrated bulletin on the WIZARD II is yours for the asking. Write today for Bulletin No. D-4150.

FISHER GOVERNOR COMPANY
Marshalltown, Iowa / Woodstock, Ontario

FISHER® Controls
SINCE 1880

"SPECIAL" Welding Fittings

by MIDWEST

"SPECIAL" DESIGNS

"SPECIAL" MATERIALS

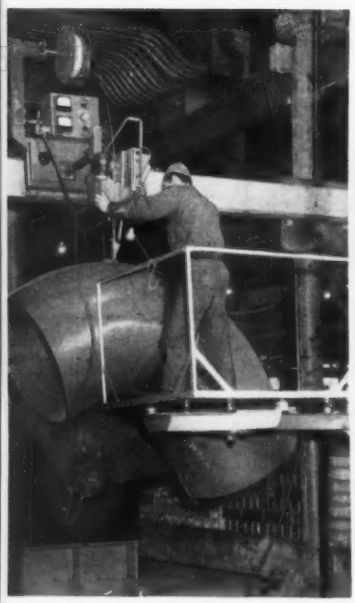
"SPECIAL" QUALITY

"SPECIAL" DELIVERY

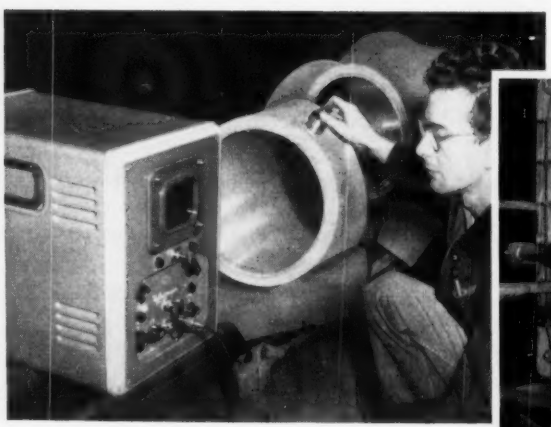
Special gauges and instruments are used to make sure that we have complied with the extremely close tolerances often required on stainless fittings. Here wall thickness and concentricity were held within extremely close limits throughout the fittings.

The exclusive Midwest method of manufacture—much more versatile and flexible than any other—enables us to make almost any type of special welding fittings to the most rigid specifications. Midwest makes welding fittings from *plate* . . . usually much easier to get than pipe, particularly if the material is special. That expedites delivery. Closer tolerances are inherent in the Midwest process, and quality control is always beyond code requirements.

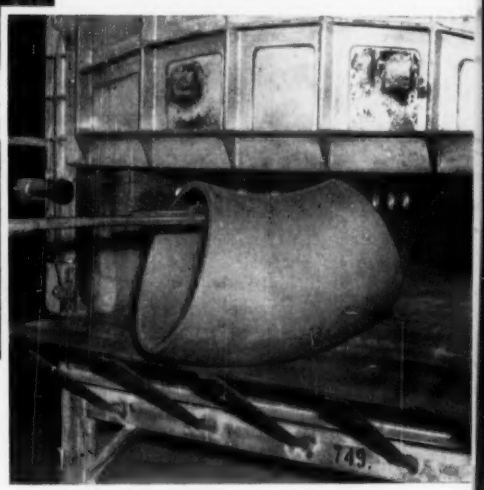
Even if you use only standard fittings, the exceptional quality of Midwest fittings can be important to you. Ask your Midwest distributor or write us for new Bulletin 5801.



36" O.D. 90° elbow with 16" tangent on one end being welded by an automatic submerged arc machine. Material is A-201 carbon steel.



Stainless-clad elbows undergoing ultrasonic inspection to check bonding of material and quality of weld. Since plate is often the only form in which clad material is available, the Midwest process is able to produce the most comprehensive range of clad fittings—and to do so promptly.



Special 24" x 21" 45° reducing elbow made of 1" thick 1¼% chrome ½% moly steel ready for heat treating furnace.

MIDWEST
PIPING COMPANY, INC.

Main Office: St. Louis 3, Mo. (P. O. Box 433)
PLANTS: ST. LOUIS, CLIFTON, N. J. and LOS ANGELES

SALES OFFICES:
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8059

Puzzled by ION EXCHANGE ?

SODIUM EXCHANGE

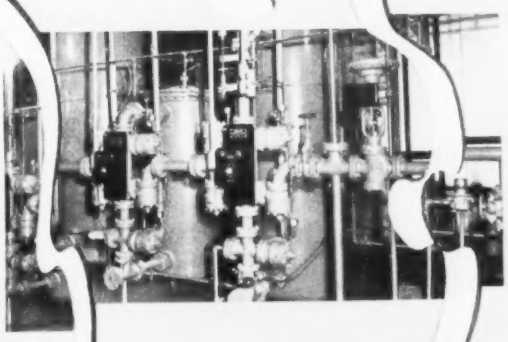
1. Softens water to zero hardness.
2. Exchanges sodium for Calcium and Magnesium hardness.
3. Does not reduce alkalinity or reduce total dissolved solids.
4. Uses inexpensive salt for regeneration.

SODIUM-HYDROGEN EXCHANGE

1. Softens water, reduces dissolved solids (with degasifier).
2. Exchanges sodium for hardness in one stream, hydrogen for all metallic ions in the other stream.
3. Reduces alkalinity to any desired value.
4. Uses salt plus acid for regeneration.

DEALKALIZATION

1. Reduces alkalinity.
2. Exchanges chlorides for non-metallic ions.
3. Does not reduce total solids or soften water, but usually preceded by sodium exchange.
4. Uses salt for regeneration. No acid required. The addition of some caustic increases exchange efficiency, and reduces effluent CO_2.



HYDROGEN EXCHANGE

1. Softens water, liberates carbonates and bicarbonates as free CO_2. Acidic effluent usually requires neutralization.
2. Exchanges hydrogen for all metallic ions.
3. With degasification, reduces alkalinity and total dissolved solids.
4. Uses mineral acids (sulfuric or hydrochloric) for regeneration.

ANION EXCHANGE

1. Neutralizes acid effluent from hydrogen exchanger to form salt-free water. Strong base type removes silica and CO_2.
2. Exchanges hydroxide for all non-metallic ions.
3. Uses caustic soda for regeneration.

DEMINERALIZATION

1. Produces mineral free water, equal to distilled quality, by combined hydrogen and anion exchange.
2. Uses acid and caustic for regeneration.

Let us help you. Our position as a leader in the field of Ion Exchange during the last thirty years assures you of optimum efficiency at lowest overall cost. ***It will pay you to investigate. Write today for Bulletin 1960.***

INFILCO

General Offices - Tucson, Arizona - P.O. Box 5033

Field offices throughout the United States and in foreign countries

INFILCO

The ONLY company IMPARTIALLY offering equipment for ALL types of water and waste processing—coagulation, precipitation, sedimentation, flotation, filtration, ion exchange and biological treatment.

58401

Research-Cottrell

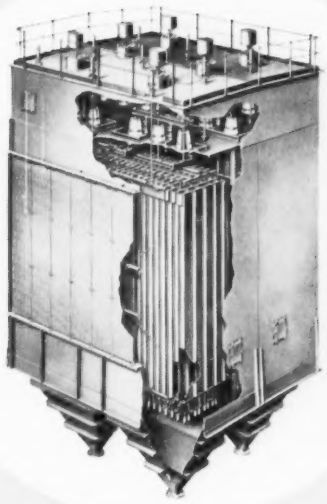
makes all three

3

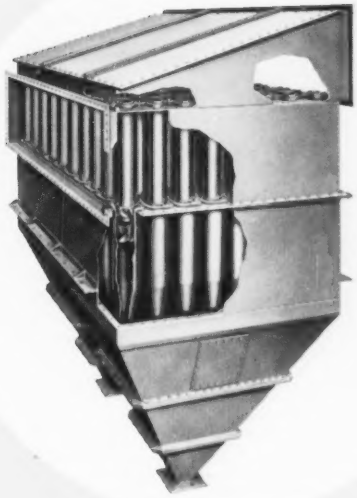
All three Research-Cottrell dust collectors are engineered for specific fly ash applications. Research's experience as the world's largest manufacturer of precipitators is well known. Over 600 straight and combination fly ash precipitators have been installed throughout the United States and Canada. • Research's Cyclo-trell, available since 1956, has already set new standards of efficiency for mechanical dust collectors. • For more information on Research-Cottrell's line of engineered dust collecting equipment, write for Bulletin PC.

Research-Cottrell

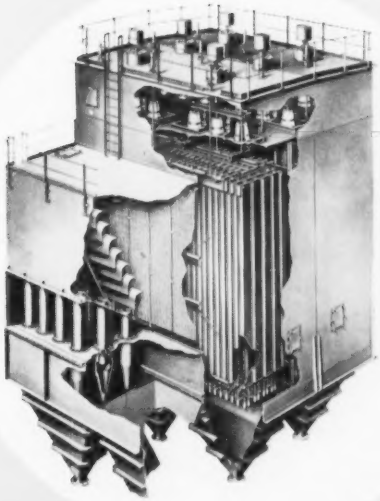
RESEARCH-COTTRELL, INC. Main Office and Plant: Bound Brook, N. J. • 405 Lexington Ave., New York 17, N. Y. • Grant Building, Pittsburgh 19, Pa. • 228 N. La Salle St., Chicago 1, Ill. • 58 Sutter Street, San Francisco 4, Calif. • Research-Cottrell (Canada) Ltd., 33 Bloor Street East, Toronto 5, Ontario.



Cottrell
Precipitators



Cyclo-trell
Mechanical Collectors



Combination
Electrical-Mechanical
Collectors

SECONDARY UNIT SUBSTATIONS

① **Incoming Section:** Terminal chambers; disconnecting and interrupter switches; roof bushing; metal-clad type HV/switchgear. ② **Transforming Section:** Askarel or oil-immersed type transformers; ventilated dry type transformers; sealed dry type transformers. All manufactured at I-T-E in Philadelphia. ③ **Outgoing Section:** The new K-Line of low voltage switchgear featuring manually charged or motor charged stored energy quick-make circuit breakers, and all with the closed door drawout feature.

I-T-E assumes all responsibility for your substation requirements

When you place an order for an I-T-E secondary unit substation, you can forget detailed planning, paperwork and the problems of coordinating delivery. I-T-E assumes complete responsibility. It engineers the unit to meet your requirements. It builds the transformers and switchgear. It assembles the complete unit under one roof, testing it to assure ease of installation and top performance. It ships the unit *as one package*, from one location, and ready to install.

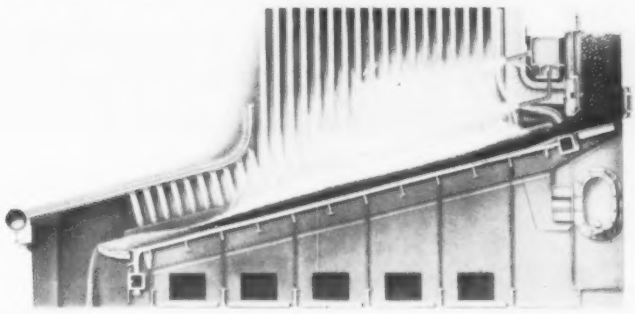
Typical of the extra values found only in I-T-E secondary unit substations is the new quick-make K-Line of low voltage switchgear. A manually charged mechanism in each circuit breaker stores energy in the first 90% of pulldown handle travel, releases it in the last 10%. It also features racking to all positions—connected, test and disconnected—while doors are closed. Both features greatly increase operator safety and reduce maintenance problems. I-T-E secondary unit substations can be supplied for any application, indoor or outdoor, and in any standard rating. For details, contact the I-T-E sales office nearest you. Or write Switchgear Division, I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Phila. 30, Pa. In Canada: Eastern Power Devices Ltd., Port Credit, Ontario.

I-T-E CIRCUIT BREAKER COMPANY
PHILADELPHIA • PENNSYLVANIA

REPORT FROM THE HOME OF JOHNSON'S WAX ON

Sketch of the Johnson's Wax administration and research center.

3 FULL SEASONS' OPERATION WITH AE VIBRA-GRATE STOKER



Side elevation of a typical Vibra-Grate Stoker installation

Mr. Adrian R. Wilson, Assistant Power Plant Manager, says this about the AE Vibra-Grate Stoker now in its 4th year of operation at the Racine, Wis., plant of S. C. Johnson & Son, Inc.:

★ Never an unscheduled shutdown during 10 months' continuous operation in each of 3 years.

★ Cost of repair parts approximately one cent per ton of coal burned . . . total cost slightly less than $200 while burning 20,169 tons.

★ Evaporation rate of 11.3# of steam to 1# of coal . . . 19% improvement over figures before installation of Vibra-Grate.

★ Continuous operation at 150 psi . . . load swings of 15,000 - 20,000# with only 3# to 4# variation in pressure.

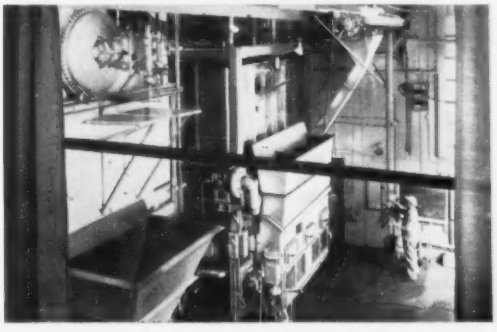
★ Smoke and fly ash eliminated almost entirely, even in load range of 5,000 - 40,000# per hour. No fly ash collector needed. Since our plant is located in a residential area, elimination of these nuisances is extremely important from the public relations standpoint.

★ No trouble with clinkering or coking coals . . . they burn out to not more than 3% combustible.

★ A great variety of types and grades of fuel used without difficulty; low grade coals, wet bark mixed with coal, wood, sawdust, shavings, etc.

The AE Vibra-Grate Stoker is designed to produce steam at the lowest possible cost per pound. Feeding and moving the fuel automatically by intermittent vibrating motions, the Vibra-Grate insures even distribution and avoids efficiency-reducing holes or light spots in the fuel bed. Its highly effective water-cooling system guarantees long grate life and minimum maintenance.

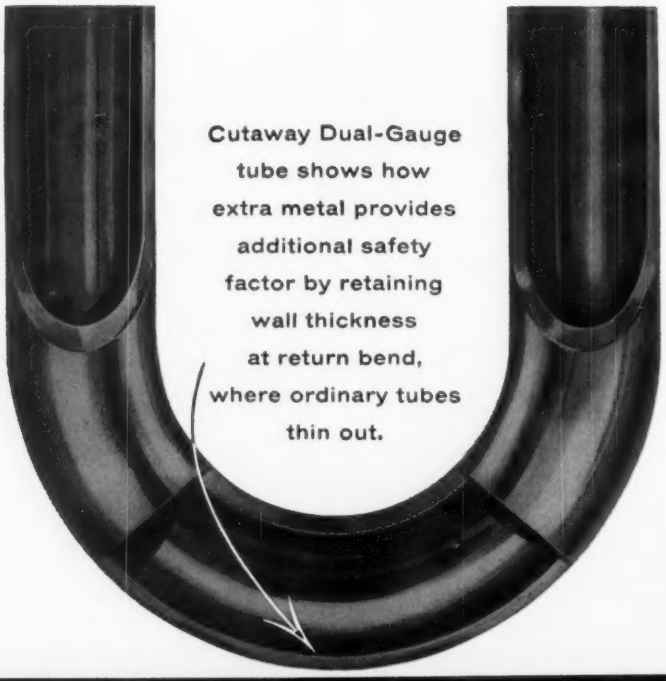
Years ahead of its time in design and performance, the Vibra-Grate offers you higher-than-ever efficiency at low over-all cost. If you're modernizing or replacing your power plant, write for details of the AE Vibra-Grate Stoker . . . you'll find it pays.



The Vibra-Grate as viewed from Mr. Wilson's office

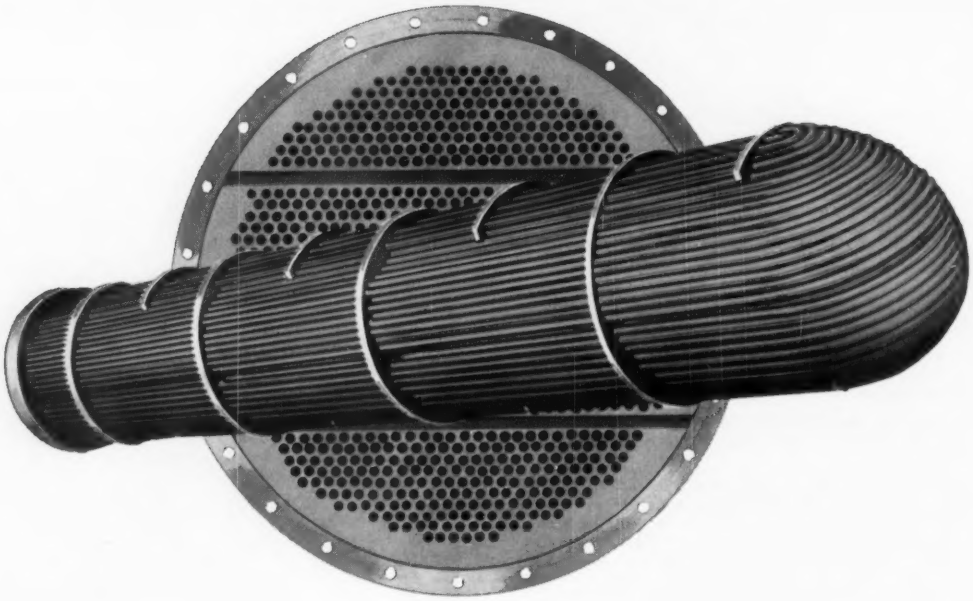
AMERICAN ENGINEERING COMPANY
Wheatsheaf Lane and Sepviva Street
Philadelphia 37, Pennsylvania

Canadian Subsidiaries: Affiliated Engineering Corporations, Ltd., Montreal, P.Q., Bawden Industries Ltd., Toronto, Ont.



Specify

DUAL-GAUGE



First for Lasting Quality—from Mine to Market!

To keep tubes uniformly strong
in condensers, feed water heaters,
heat exchangers and similar equipment . . .

PHELPS DODGE

TUBING!

Provides heavier wall thickness:

a. At one or more points in tube length to compensate for thinning on outer portions of return bends.

b. At points of support.

c. At tube ends to meet special requirements.

Produced in all standard sizes or manufactured to the particular design requirements of individual customers.

Available in Cupro-Nickel, Red Brass, Aluminum Brass, Admiralty metal and Muntz metal.

PHELPS DODGE COPPER PRODUCTS CORPORATION
WIRE TO MARKET
REG U S PAT OFF

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass. Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

WAYS TO ARRIVE AT PROPER VENTILATION

No two ventilating systems are likely to be exactly the same. Conditions vary; so should the fans. The six examples illustrated here cover the situations most often encountered in industrial plants.

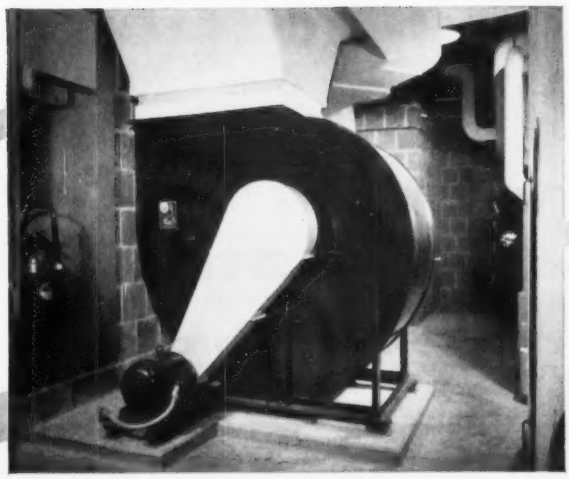
In many instances, the right combination of ventilating installations can go a long way toward modernizing existing buildings.

Better working conditions usually result in improved morale and greater worker efficiency.

While complete air conditioning is desirable, and in many cases absolutely necessary from a manufacturing standpoint, adequate ventilation many times will do a satisfactory job.

And for the best in ventilating fans, contact your local "Buffalo" Engineering Representative or write:

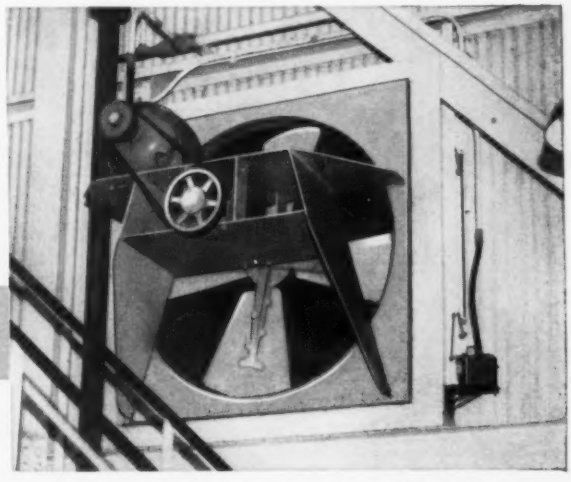
BUFFALO FORGE COMPANY, Buffalo, New York



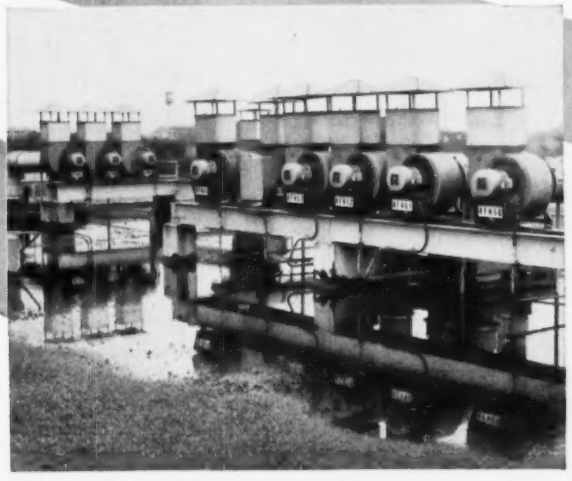
CENTRAL SYSTEM ventilation, which very often incorporates air conditioning and heating, requires the high efficiencies and capacities of large centrifugal fans. Capacities range to 500,000 cfm.

THROUGH THE ROOF is the best way to ventilate large areas where duct work is undesirable. Allows flexibility of plant layout. New models in capacities up to 250,000 cfm.

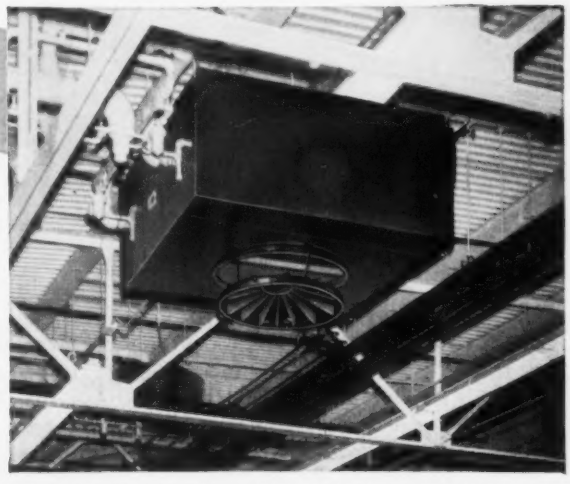
CONFINED AREA exhaust such as spray booths, hood installations, function best with efficient, powerful axial flow fans. Units easily installed in ducts.



LOWEST COST ventilation for open areas is made possible by large propeller fans. New designs offer higher efficiencies, larger capacities (250,000 cfm).



CORROSIVE FUMES can be exhausted with cast iron fans as shown. Also available are fiber glass fans, rubber and other specially coated units.



PUTTING BACK AIR exhausted is job for low cost, high capacity make-up air units. Fans, heating coils, filters, diffusers included in "package" units.

THE MARK OF QUALITY

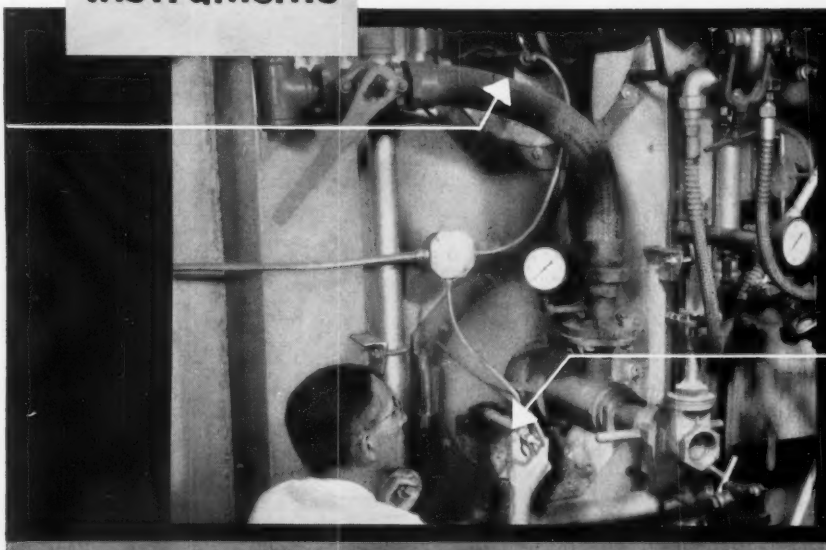
BARBER COLMAN

Wheelco Instruments

a look under the cover shows why –

Wheelco FLAME-OTROLS

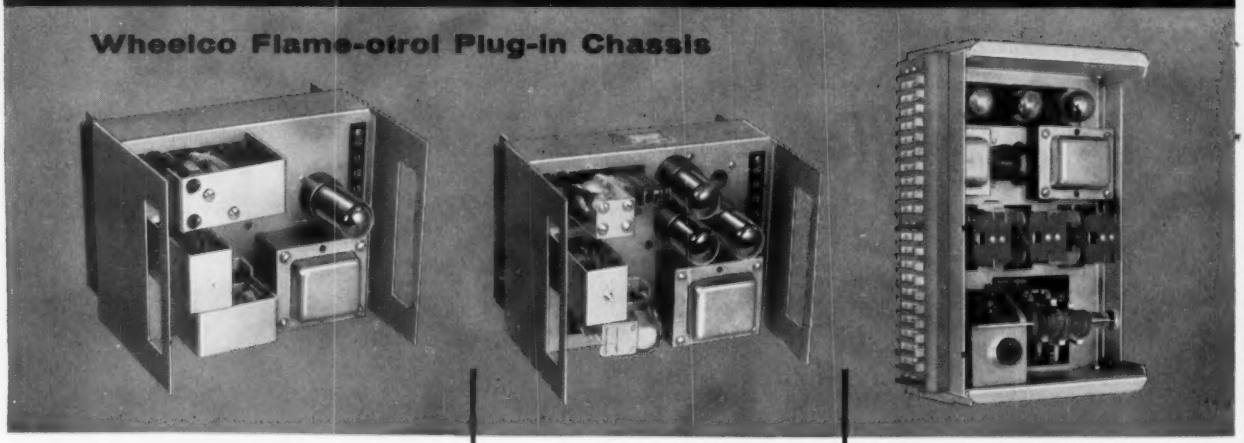
give better flame-failure protection



OIL- AND GAS-FIRED FURNACES, BOILERS, KILNS, AND DRYERS RELY ON COMPLETE LINE OF ELECTRONIC COMBUSTION SAFEGUARD SYSTEMS

Arrows indicate Wheelco lead-sulphide Flame-eye used on industrial-type combination oil-gas burners.

Wheelco Flame-otrol Plug-in Chassis



Model 1470 (manual-starting)
CONDUCTIVITY RECTIFICATION "CR" SYSTEM

. . . takes advantage of the unique features of a flame being able to conduct a small amount of electrical current with flow of electrons in direction of flame being greater than "up-stream."

Model 1570
INFRA-RED "IR" SYSTEM

Uses lead-sulphide photoconductive cell predominantly sensitive to infra-red energy as a flame pickup. It operates in conjunction with a "flame-only" type current when a flame is present and ignores constant bright background effect.

AUTOMATIC OPERATION

Two basic models (1474 and 1574) use same sensing elements as models listed above. Sequence timing for oil- or gas-fired burner or boiler operation includes: purging, warm-up proving, pilot-proving, low-fire stabilization, ignition-timing, and post-purging.

There's no need to "stretch" in order to make a combustion safeguard system fit your exact needs. From Wheelco's complete line you can select *exactly* the right Flame-otrol required by your installation — manual, semi-automatic, or fully automatic.

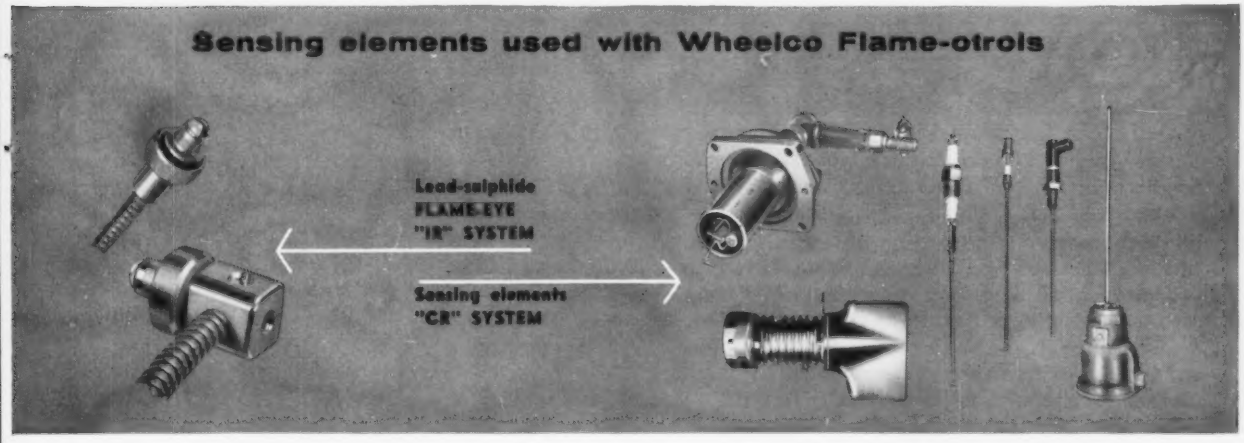
Whatever type of installation meets your requirements best, you'll be assured of getting a unit that's dependable in operation and simple to maintain. First, and foremost, there's the famous Wheelco plug-in design that conveniently enables the entire chassis to be removed for adjustment, examination, and repair.

In addition, convenient checking strips permit checking circuits and voltage with simple and readily available instruments. Standard electronic tubes are used on all Flame-otrol models, simplifying parts inventory and eliminating a possible replacement problem.

Because all Flame-otrol components are housed in a rugged, industrial-type steel cabinet, the unit operates satisfactorily in all types of plant locations. The gasketed, dust-tight, swing-out cover keeps out foreign matter that could impair operating efficiency.

Wheelco Control centers, designed with removable sections to meet changing requirements, are available to house complete combustion safeguard systems. Here, too, significant savings on installation costs and time are assured in a custom-engineered installation.

The quickest way to be sure of having a complete combustion safeguard system designed for your specific needs is to call your nearby Wheelco field engineer and let him analyze your requirements. This "no obligation" survey takes into consideration both economic and technical factors and results in a down-to-earth recommendation that insures you'll get the best possible buy for each dollar invested.



BARBER-COLMAN COMPANY

Dept. F, 1551 Rock Street, Rockford, Illinois, U. S. A.
BARBER-COLMAN of CANADA, Ltd., Dept. V, Toronto and Montreal, Canada

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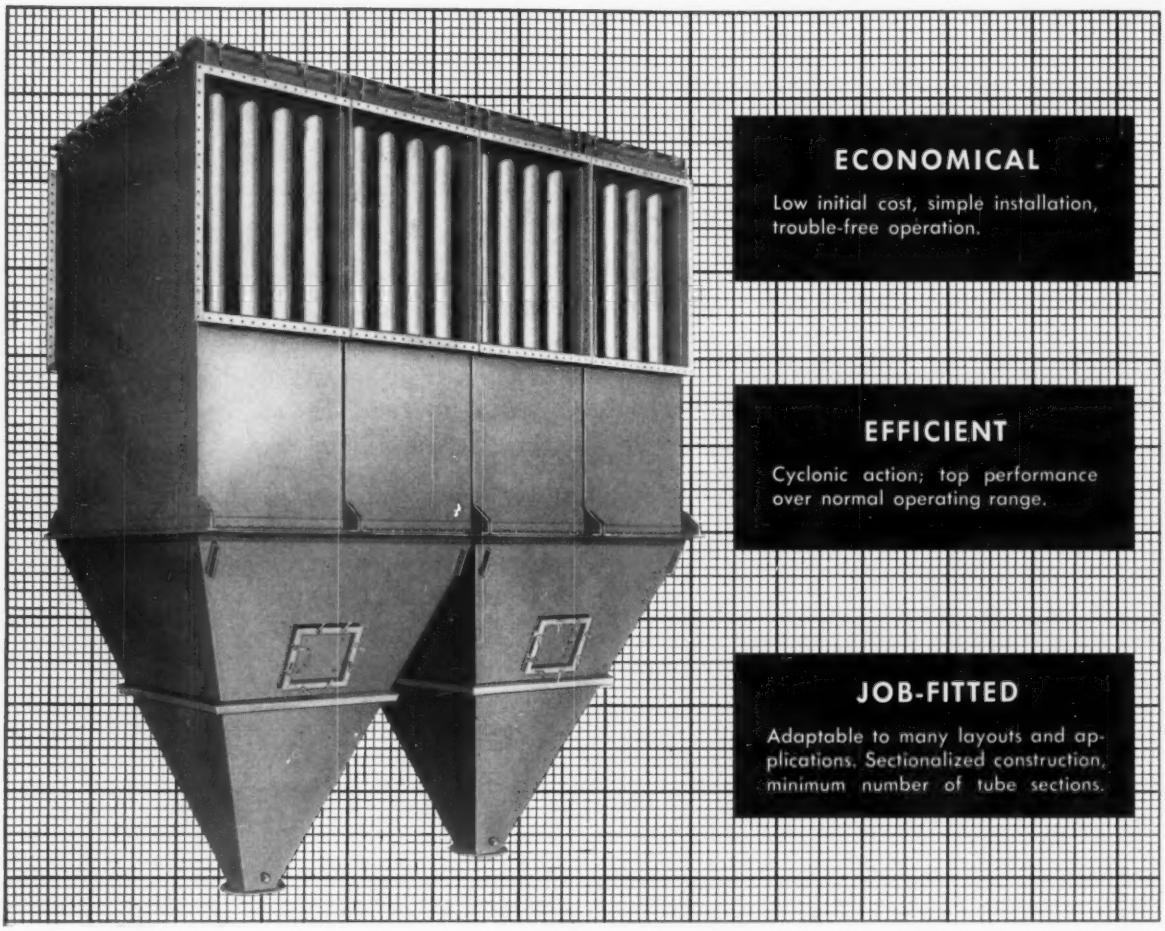
AMERICAN BLOWER PRECIPITATORS


ECONOMICAL
Low initial cost, simple installation, trouble-free operation.
EFFICIENT
Cyclonic action; top performance over normal operating range.
JOB-FITTED
Adaptable to many layouts and applications. Sectionalized construction, minimum number of tube sections.

Look into mechanical-type collecting equipment for control of dust and fly ash. You'll find that American Blower's Series 342 Precipitator offers three very practical advantages: adaptability, efficiency, and low cost.

Its sectionalized construction shortens erection time; factory-assembled tube sections are shipped to you match-marked for easy reassembly. And since each tube assembly is basically an individual cyclone or dust collector, the multi-tube Series 342 delivers an over-all performance comparable to the high efficiency of a small-diameter cyclone collector.

For your specific efficiency and pressure-drop requirements, a variety of tube designs and arrangements are available — in either steel or cast-iron. You may choose top, slant, or back outlet. (Front inlet is standard.)

All units feature readily removable inlet and outlet tubes to facilitate servicing; back-outlet construction has easily removed top covers. Access door on each hopper permits quick inspection.

Why not discuss your dust-collection problem with an American Blower sales engineer? He offers a complete line of fly ash precipitators and dust collectors for public utilities and industrial plants — and his application experience may prove most helpful to you. Call your nearby American Blower branch office, today. Or write: American-Standard,* American Blower Division, Detroit 32, Mich. In Canada: Canadian Sirocco products, Windsor, Ont.

*American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation.

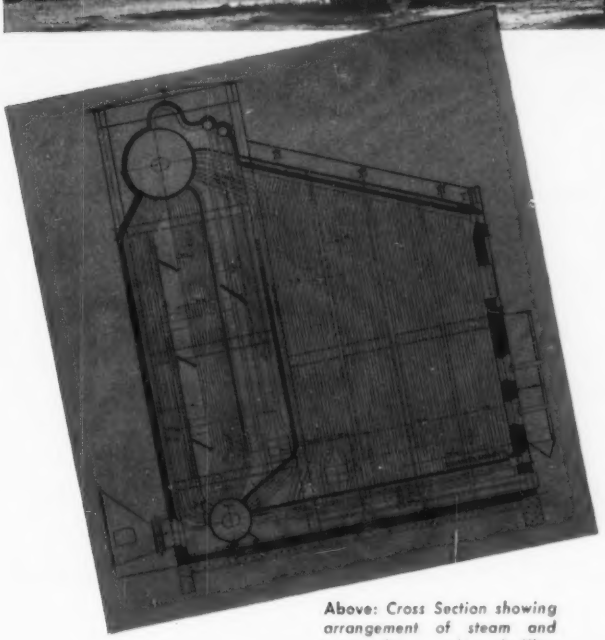
American-Standard Products

AMERICAN-Standard

AMERICAN BLOWER DIVISION

Vogt STEAM GENERATORS

at SUNTIDE REFINING COMPANY
Viola, Texas



Above: *Cross Section showing arrangement of steam and water drums, tubes, baffles, and furnace.*

EFFICIENCY AND ECONOMY PROVED BY FIRST 3 UNITS . . . 2 MORE ADDED!

Principle Data Each Unit

- 85,000 pounds steam per hour capacity, designed for 500 lbs. S.W.P. and 625° F. total temperature.
- Water cooled furnace.
- Burners for Gas and Oil fuel.

Vogt offers a complete line of custom built and package type steam generators. Available in bent tube and straight tube designs for solid, liquid, or gaseous fuels burned singly or in combination.

Write for bulletins. Dept. 24A-BP

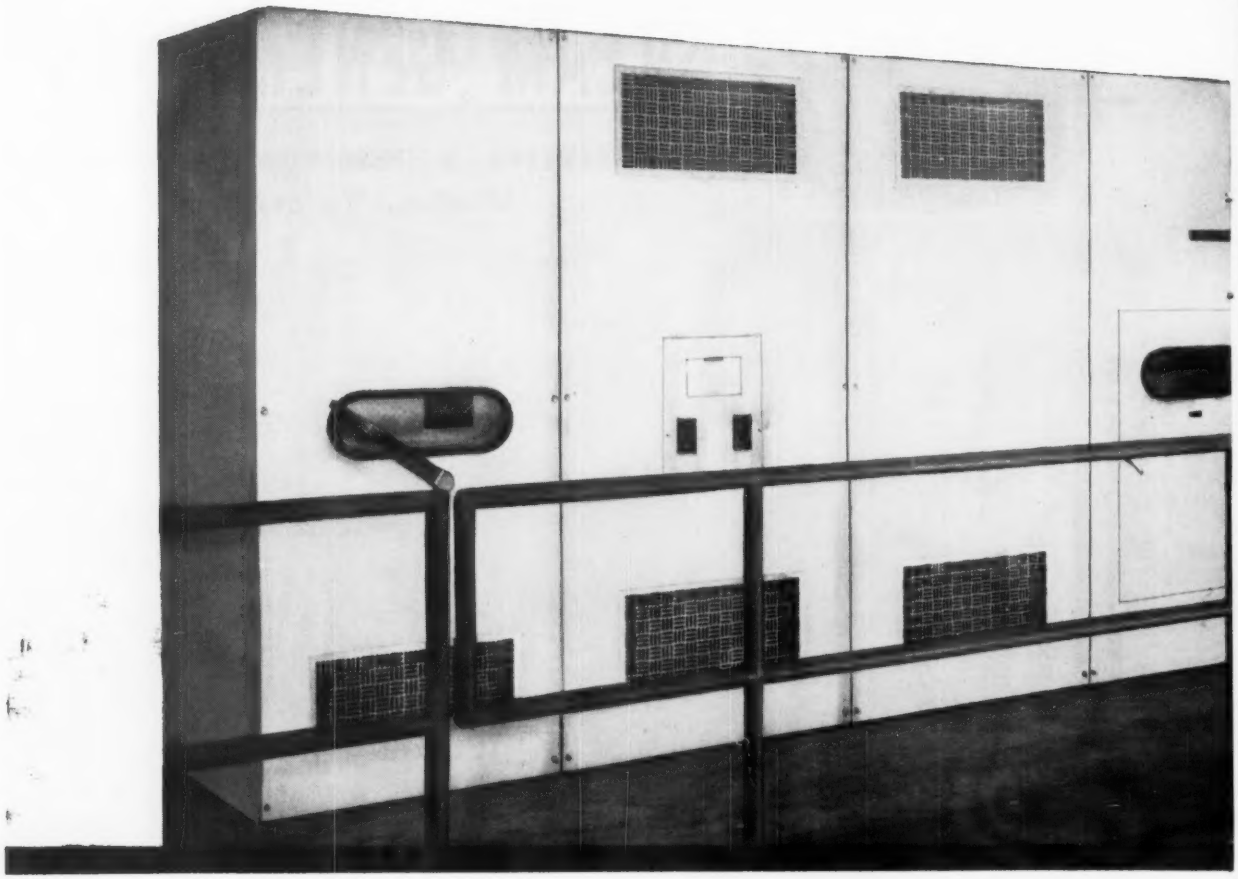
OTHER VOGT PRODUCTS

Drop Forged Steel Valves, Fittings and Flanges—
Petroleum Refinery and Chemical Plant Equipment
Heat Exchangers
Ice Making and Refrigerating Equipment

HENRY VOGT MACHINE CO.

Box 1918, Louisville 1, Kentucky

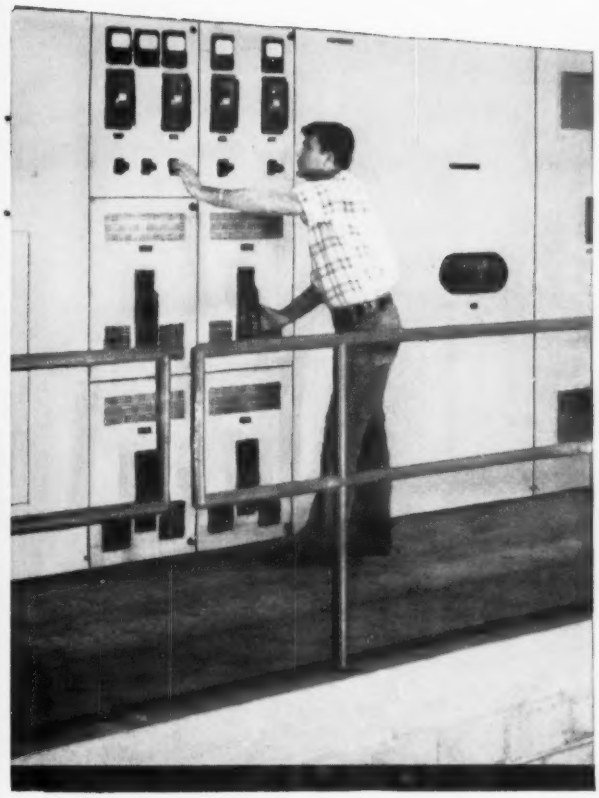
SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va., Cincinnati



POWER-UP

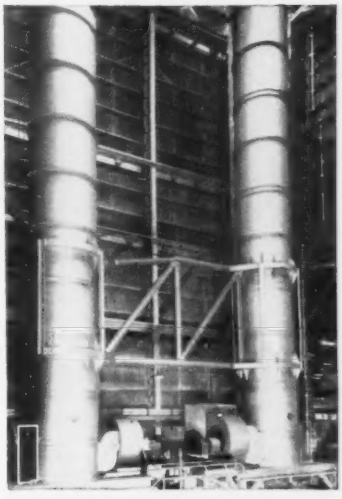
HARVEY ALUMINUM *did...*

doubled capacity, achieved more economical production than ever before!

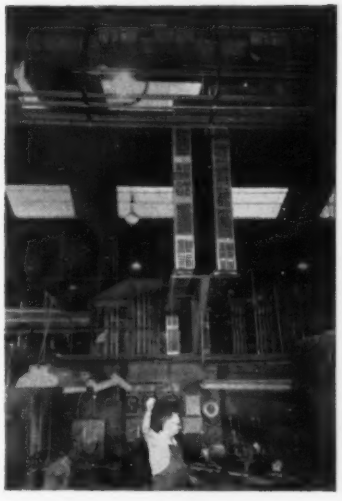


Seven Westinghouse spot network power centers located in major production areas supply motor loads, induction and resistance-type furnaces and the mercury lighting system.

"The Westinghouse 480-v color-corrected mercury-vapor lighting system is remarkably superior to conventional lighting," says Mr. Lawrence Harvey, Executive Vice President. "It is not only less expensive to operate at the same level of illumination, but replacement and maintenance costs are reduced."



Twin 110' Westinghouse electric furnaces are powered by a specially engineered system providing for cyclical furnace loads, and at the same time, making maximum use of network capacity.



Westinghouse bus duct, carrying power throughout the plant, is another key to distribution system flexibility. Here, two runs of ventilated low-impedance duct from the transformer feed individual branch runs of 1000-amp plug-in duct.

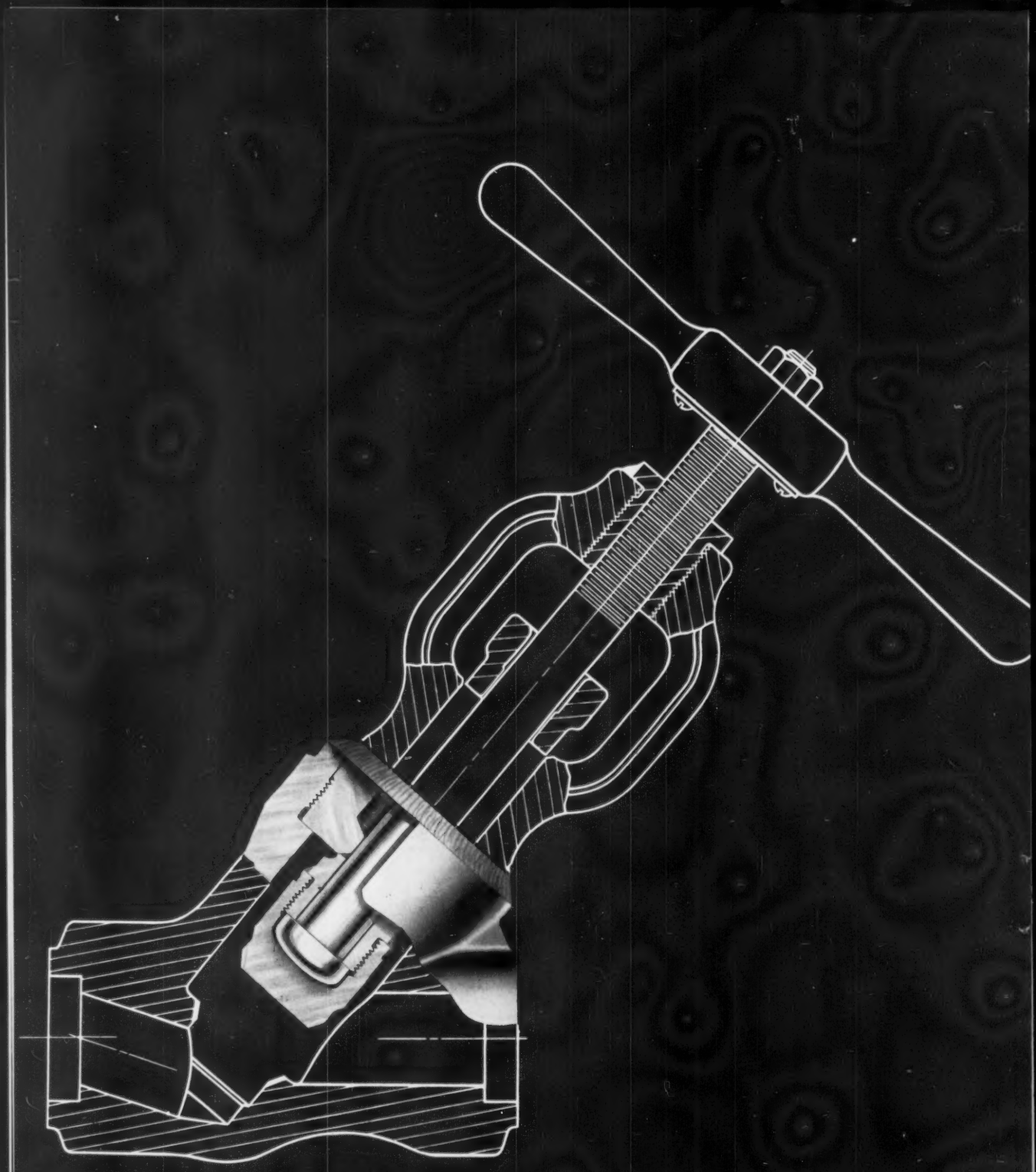
Harvey Aluminum doubled productive capacity and cut per-pound production costs as well. Their large-scale expansion program had called for extrusions of unprecedented weight and dimensions. Investigation proved that flexible high-voltage electrical distribution was the primary power requirement. Two incoming circuits at 13.8 kv established primary voltage. A spot network system, comprised of seven load centers, was installed at major load points and serves equipment throughout the plant through low-impedance and plug-in bus duct. This basic system is ideal for unbalanced and shifting furnace-heating loads.

Service continuity is assured, and voltage regulation has measurably improved. Future relocation of machinery and unpredictable changes of equipment, too, have been provided for. This high order of electrical planning has helped maintain Harvey's position as one of the world's lowest cost producers of fabricated aluminum.

Is yours a problem of production changeover, new products, or rising costs and a profit squeeze? Your electric utility sales engineer or your Westinghouse representative can help you with a practical solution . . . Power-Up!

J-97218-A

YOU CAN BE SURE...IF IT'S Westinghouse



EDWARD UNIVALVE

What's New from Edward Valves, Inc.

New Products . . . Problems and Solutions. . . Information on Steel Valves from Edward, Long-Time Leader in the Field!

Shoulder, thread and weld make

Superior "Univalve" Body-Bonnet Joint

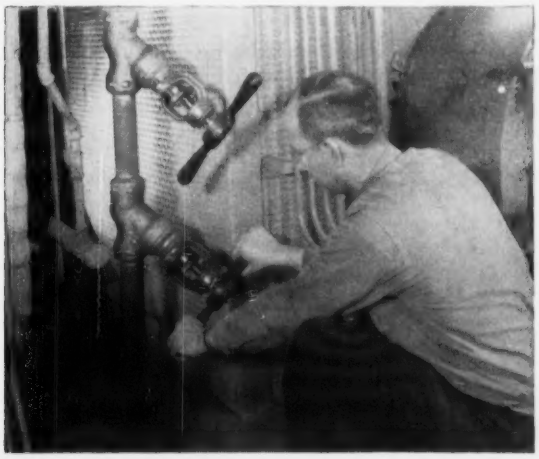
Edward valve researchers were assigned three main goals in developing the Univalve* . . . first, design a globe valve for high pressure-temperature service—that would *stay* leak-proof . . . second, eliminate—as far as possible—the necessity for maintenance . . . third, fabricate all pressure-containing parts of forged steel for maximum strength and soundness.

How well they succeeded is illustrated by this fact: in many hundreds of advanced temperature-pressure applications all over the world, Edward Univalves have given consistently superior service. The *reason* for this is simple . . . Univalves, properly maintained, simply do not leak.

WELD SEALS JOINT

In the Univalve, a bead of fine-grained weld seals the body-bonnet joint to maintain perfect pressure tightness in any service. A guiding section above the threads protects them from the seal-weld; the threaded section and body shoulder carry the pressure load and insure accurate alignment. The rugged threaded bonnet—with opening just large enough to accommodate the stem—provides a pressure-tight backseat. The radiused disk nut contacts the beveled bonnet backseating surface . . . isolates packing from line pressures and temperatures . . . stretches packing life.

While the Univalve rarely needs attention, even its tough integral Stellite seating surface *can* become scored under some conditions. To strip for inspection and possible re-lapping, the seal-weld is easily removed by machining or grinding or with carbon arc or oxy-acetylene scarfing tip. Besides simple disassembly and positive backseat advantages, Univalve's one-piece gland eliminates possible small parts loss during repacking.



IDEAL FOR BLOW-OFF SERVICE. Univalves meet ASME Code for blow-off service and are adaptable for all high pressure installations.

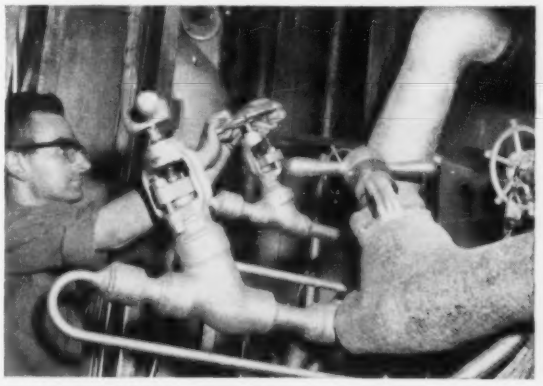
IMPORTANT UNIVALVE FEATURES:

Streamlined Flow Path reduces pressure drop, minimizes wear-producing turbulence. Univalve meets requirements for blow-off service.

Simple Packing Adjustment keeps packing maintenance down. Sturdy gland bolts, roomy yoke, one-piece forged gland.

Easy Open—Tight Close Operation of all Univalves 1¼" to 2½" made a reality with the exclusive Edward Impactor* handle.

Continuous Stellite Ring applied to body and disk, retains hardness under temperature and resists wear.



4500 LB UNIVALVE in service at Ohio Power Company's supercritical Philo station.

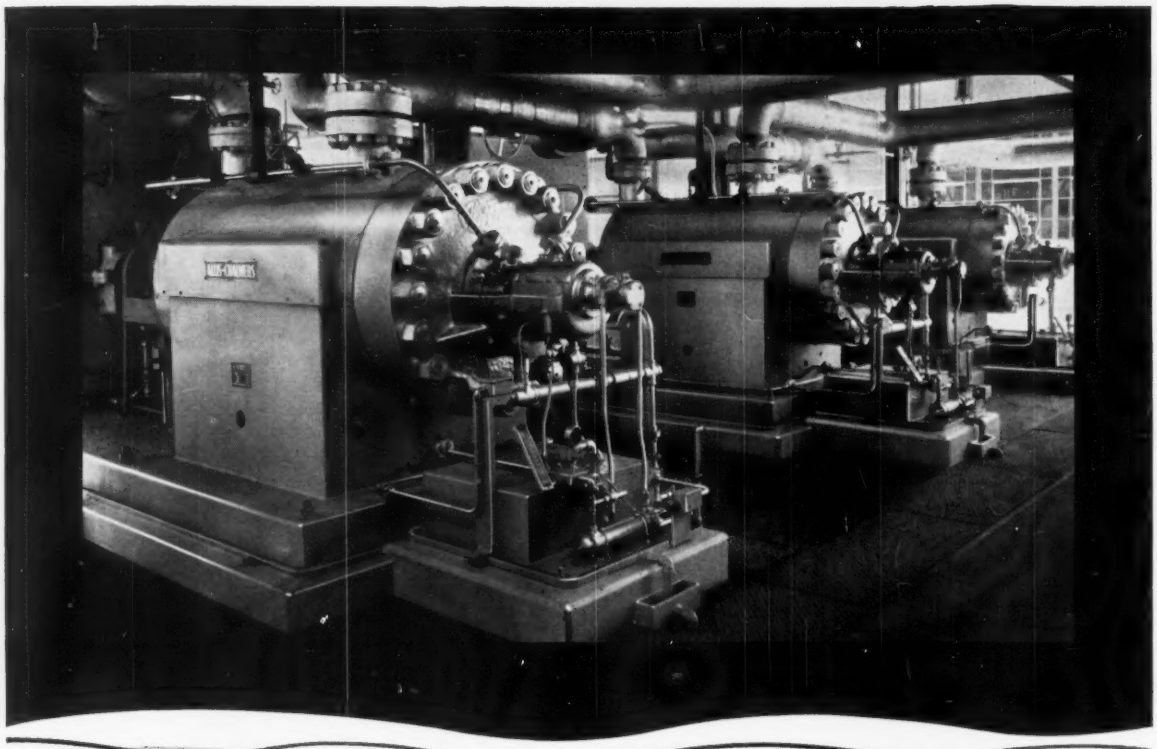
*T.M. Reg. U.S. Pat. Off.

EDWARD VALVES, INC.

Subsidiary of ROCKWELL MANUFACTURING COMPANY

1230 West 145th Street, East Chicago, Indiana

Edward builds a complete line of forged and cast steel valves from ⅛" to 18"; in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs; for pressures up to 7500 lbs; with pressure-seal, bolted, union or welded bonnets; with screwed, welding or flanged ends.



There's NO radial thrust in Allis-Chalmers boiler feed pumps

Result: *Smoother running*

SEE HOW Allis-Chalmers boiler feed pumps are constructed. The above model is available for inspection right in your own office. Call your A-C representative or write us.

. . . and this Allis-Chalmers design also pays off in uniform ring and bushing clearances. Balanced thrust also increases the life of close clearances and packing because shaft vibration is eliminated.

In addition to balanced thrust, A-C barrel-type boiler feed pumps are finding ever-greater use in power installations for these reasons:

- First stage has twin single-suction impellers to give low NPSH requirement for highest efficiency under fluctuating loads.
- Expansion joint and shaft seals are brought to outside of pump where they may be easily inspected and maintained.
- You get choice of gland sealing in entire line of pumps from 300-5000 gpm, 1200-4000 psig.

Contact your A-C representative, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-5708

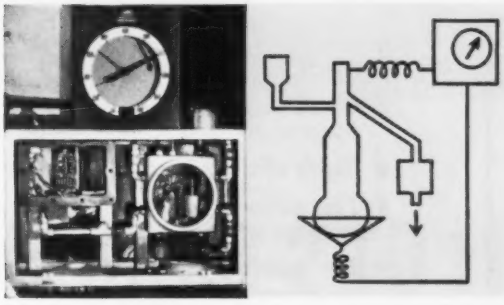
Nothing gets by

Automatic end-point testing device developed by Standard Oil research men makes certain of the uniform quality of gasoline and diesel fuel delivered to you.

Scientists at Standard Oil never stop in their drive to improve and then improve again the uniform quality of the petroleum products that bear the Standard Oil trade-mark. These engineering research scientists have now created wholly new instruments for performing near continuous physical analysis *automatically.*

One such instrument automatically performs the physical analysis that determines end-point. Using it, refineries maintain a continuous inspection of the temperature at which diesel fuels are completely distilled. To you, this means that Standard is able to maintain a constant control over the uniformity and high quality of the fuels you use to power your diesel engines. It also means that Standard Oil power-producing petroleum products, with their constantly controlled end-point, burn uniformly, give you uniform high performance.

This is part of the research pay-out, the "something more" research builds into the products you buy from Standard. This is your return from Standard's investment in research. And now there are 48 district offices in the 15 Midwest and Rocky Mountain states to serve you. Call the one nearest you. **Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.**

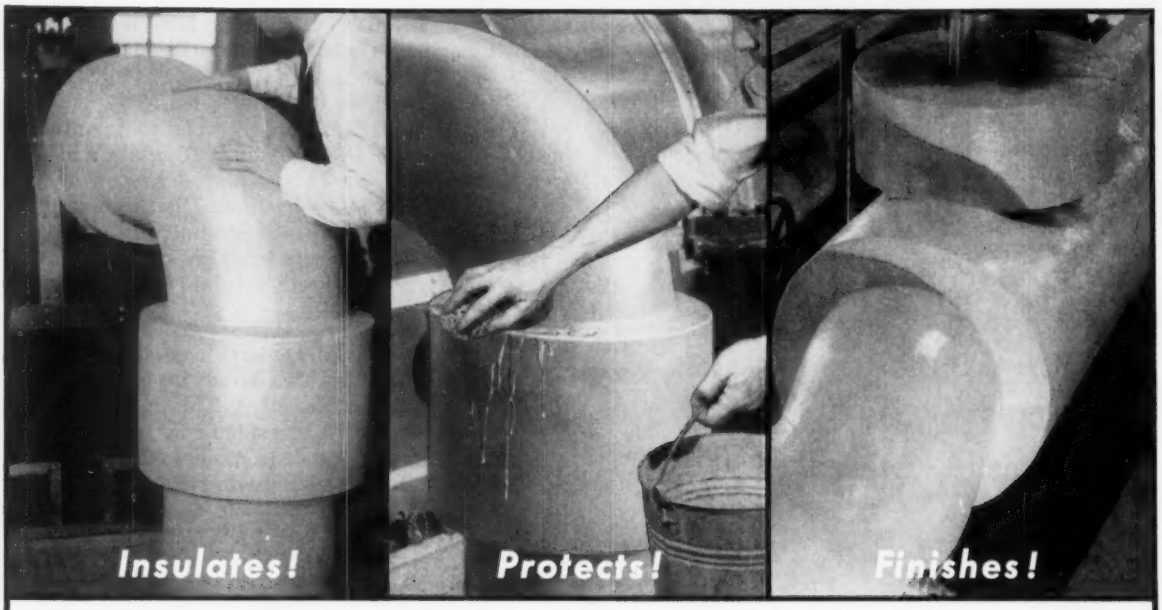


Automatic end-point tester works this way. A small sample is placed in an electrically heated flask. The temperature is measured and recorded during a heating cycle when distillation is accomplished. Distillate is condensed and drained, the flask temperature is lowered by introduction of the next sample, and the apparatus is ready for another test.

You expect more from STANDARD and get it!

1 QUICK APPLICATION INSULATES, PROTECTS, FINISHES!

EAGLE-PICHER
ONE-COTE CEMENT



- Saves time, work, money! One quick application provides smooth, light reflectant surface on hot or cold equipment!
- Clean, easy to handle! Just trowel it on—even on irregular areas where application of other insulations is often impractical.
- Highly efficient! Effective insulation at temperatures up to 1000 F.
- For outdoor installations! Quick-setting, withstands rain and moisture two hours after application. Prevents rust!
- For indoor installations! Requires no wire mesh or finishing treatment!

FREE SAMPLE!

Write today!

Prove to yourself, on your equipment, how Eagle-Picher One-Cote Cement can save you time, money and valuable man-hours.

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

Since 1843

EAGLE EP PICHER

EAGLE-PICHER

The Eagle-Picher Company • General Offices: Cincinnati 1, Ohio

(Member of Industrial Mineral Fiber Institute)

compressor-user survey shows

FEATHER VALVE PREFERRED 2 TO 1!

FEATHER VALVE

VALVE A

VALVE B

A recent survey of compressor users put the amazing Feather*Valve first by far in all four operating categories —simplicity of construction, efficiency, low maintenance cost and quiet operation. In addition, the Feather Valve was picked as the preferred compressor valve 2 to 1 over the nearest competing type of valve!

The lightest, fastest-acting valve available, the amazing Feather Valve provides very sharp action with virtually no slip or back-flow. It works with no impact . . . has no buffer plates or cushioning devices. Practically indestructible it assures long life with negligible maintenance costs. When buying your next compressor, look into Worthington's complete line of Feather Valve units. Worthington Corporation, Harrison, N. J.

*REG. U. S. PAT. OFF.

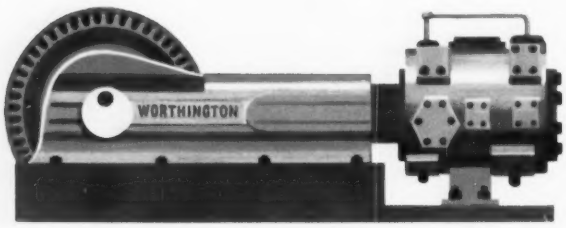
WORTHINGTON

NO COMPROMISES

when you select from Worthington's complete compressor line

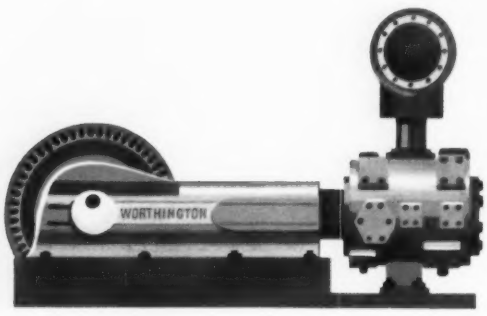
The Worthington line includes a compressor and drive for *every* compression job. Sizes range up to 10,000 hp and gas pressures to 35,000 psi. In addition to the types shown below, Worthington builds many others including steam engine, steam turbine, and engine driven machines in many types and sizes. For more information write specifying the bulletin noted below to Worthington Corporation, Section 36.1, Harrison, N. J. In Canada: Worthington Canada Ltd., Brantford, Ont.

WORTHINGTON

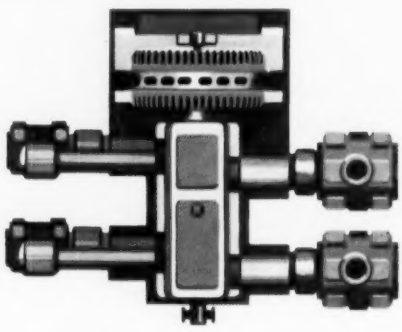


Single horizontal compressor, type HB
5 to 150 hp—Bulletin L-640-B1E

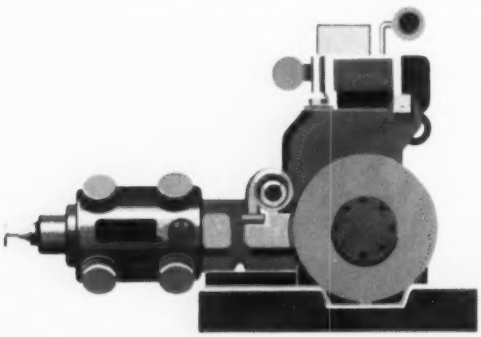
Vertical angle compressor, type YC & DYC
75 to 500 hp—Bulletin L-676-B1A



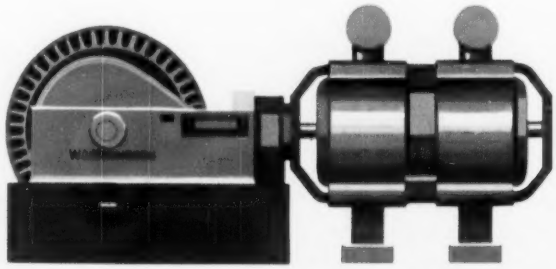
Horizontal duplex compressor, type DC
250 to 3,000 hp—Bulletin L-675-B1C



Balanced opposed compressor, type BDC
400 to 10,000 hp—Bulletin L-679-B1A

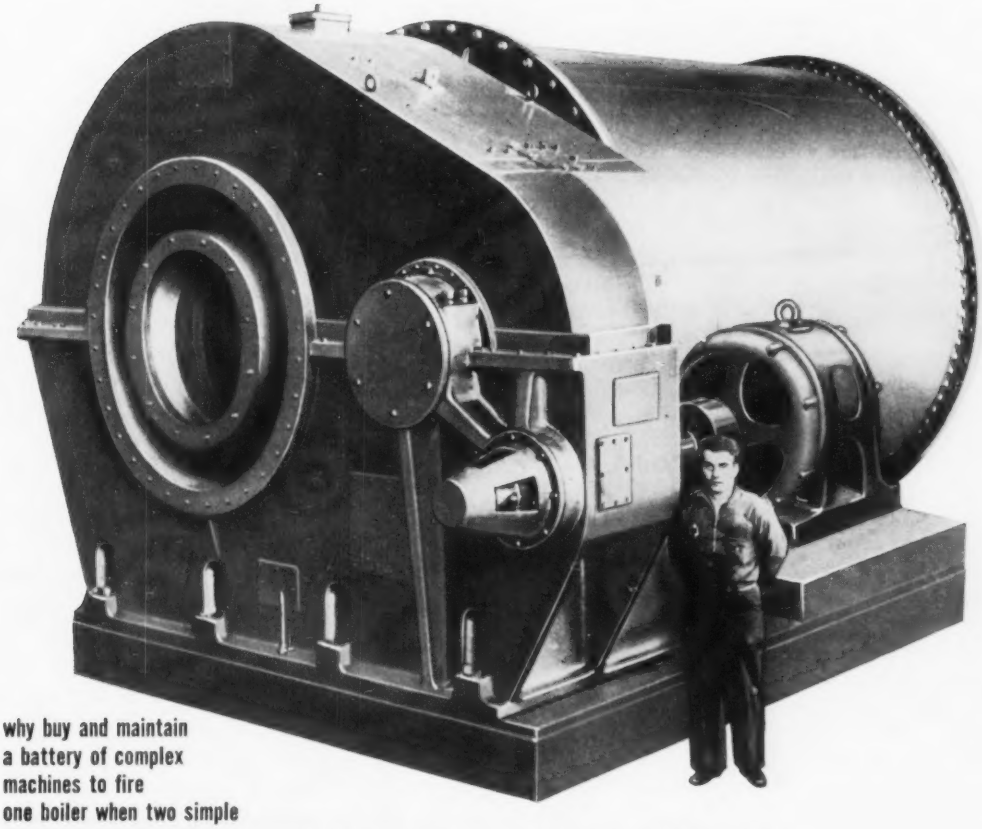


Angle gas-engine compressors, types SLHC and SUTC
375 to 2,500 hp—Bulletin S-550-B27; S-550-B23D



Vacuum pump, 200 to 150,000 CFM—Bulletin L-600-B9-4

2=7



why buy and maintain a battery of complex machines to fire one boiler when two simple

KENNEDY AIR SWEPT BALL MILLS will do a better job

When you buy a KENNEDY Pulverized Coal Firing System for your power plant, you save on first cost, maintenance, space and equipment.

You install *ONE* machine—not *THREE* or *FOUR!*

KENNEDY mills pulverize coal to 50 Tons/hr. —or more.

You buy *ONLY* the capacity you need! You don't invest in extra standby mills to offset continual maintenance.

You spend less on upkeep. With KENNEDY Mills, routine maintenance is done during the annual boiler inspection. Grinding media is replaced any time, *without shutdown!*

You can use the cheapest fuel obtainable—high ash—high moisture—low grindability—low B.t.u. Only KENNEDY Air Swept Ball Mills provide this versatility.

with a KENNEDY SYSTEM—you'll spend less!

KENNEDY-VAN SAUN

MANUFACTURING & ENGINEERING CORPORATION

405 PARK AVENUE, NEW YORK 22, N. Y. • FACTORY: DANVILLE, PA.

ANOTHER REPUBLIC ENGINEERING ACHIEVEMENT!

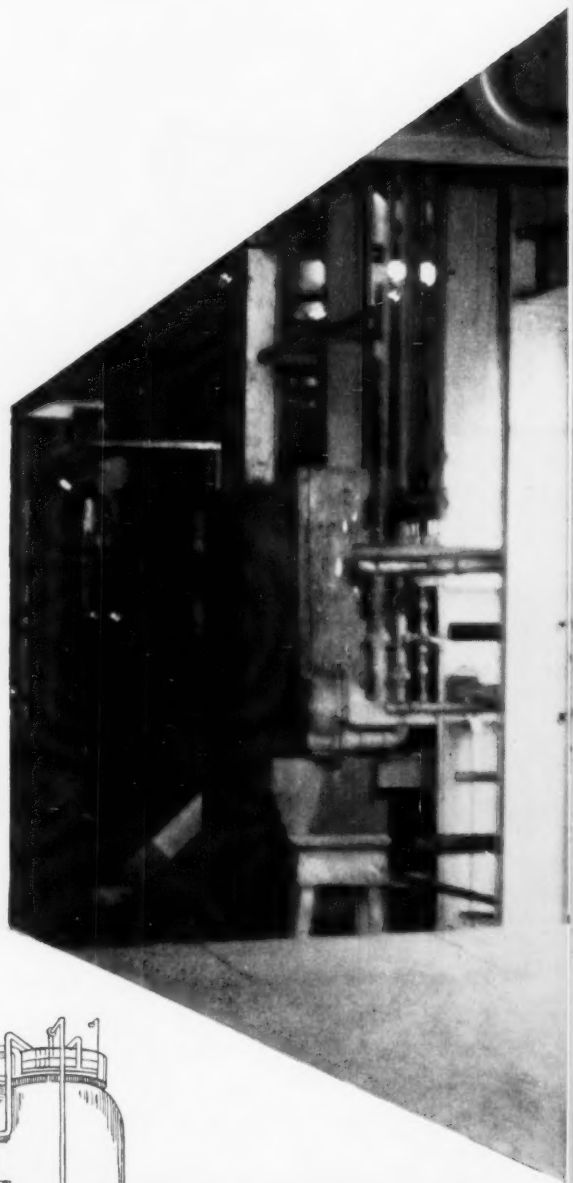
Republic Controls Maintain Efficient Production of 5,000,000 Gallons of 330F Water Per Day

. . . at Pan American Sulphur Company, Jáltipan, Veracruz, México

At Pan American's Jáltipan plant, six 100,000 lbs/hr fuel oil fired boilers generate the steam required to heat the hot water needed to produce in excess of 1,000,000 tons annually of Frasch sulphur. Each boiler, furnished with F.D. and I.D. fans and steam atomizing oil burners, is controlled by a Republic pneumatic combustion control system. Feedwater to individual boilers is controlled by a Republic single-element system, consisting of drum-level transmitter, controller, manual-automatic station and valve.

Republic's performance on this job has been outstanding. The control system has functioned without difficulty, day in and day out, since installation in 1954. This record stands, despite exposure to the damp, torrid climate of southern Mexico, where 100% relative humidity and 130F temperatures are common. Personnel recruited from the immediate area were trained on the job, and have operated the plant since its completion.

Republic's experience with plants of all sizes, all pressure and temperature ratings, and all load characteristics is your best guarantee of getting all the premium performance built into your major equipment. A technically-trained, thoroughly experienced Republic Engineer is ready to discuss your instrument and control problems. Republic sales offices are located in principal cities throughout the United States and Canada.

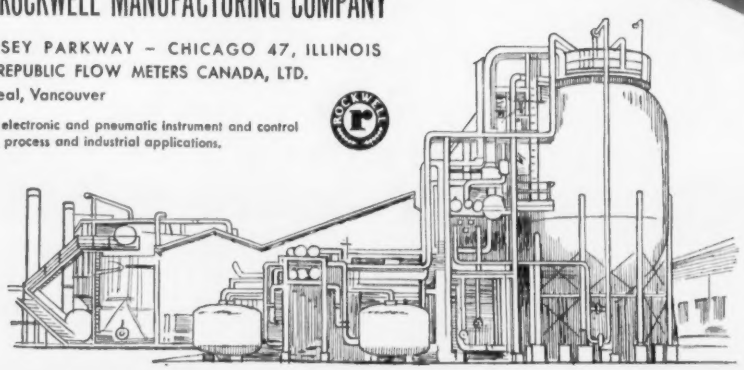


REPUBLIC FLOW METERS CO.

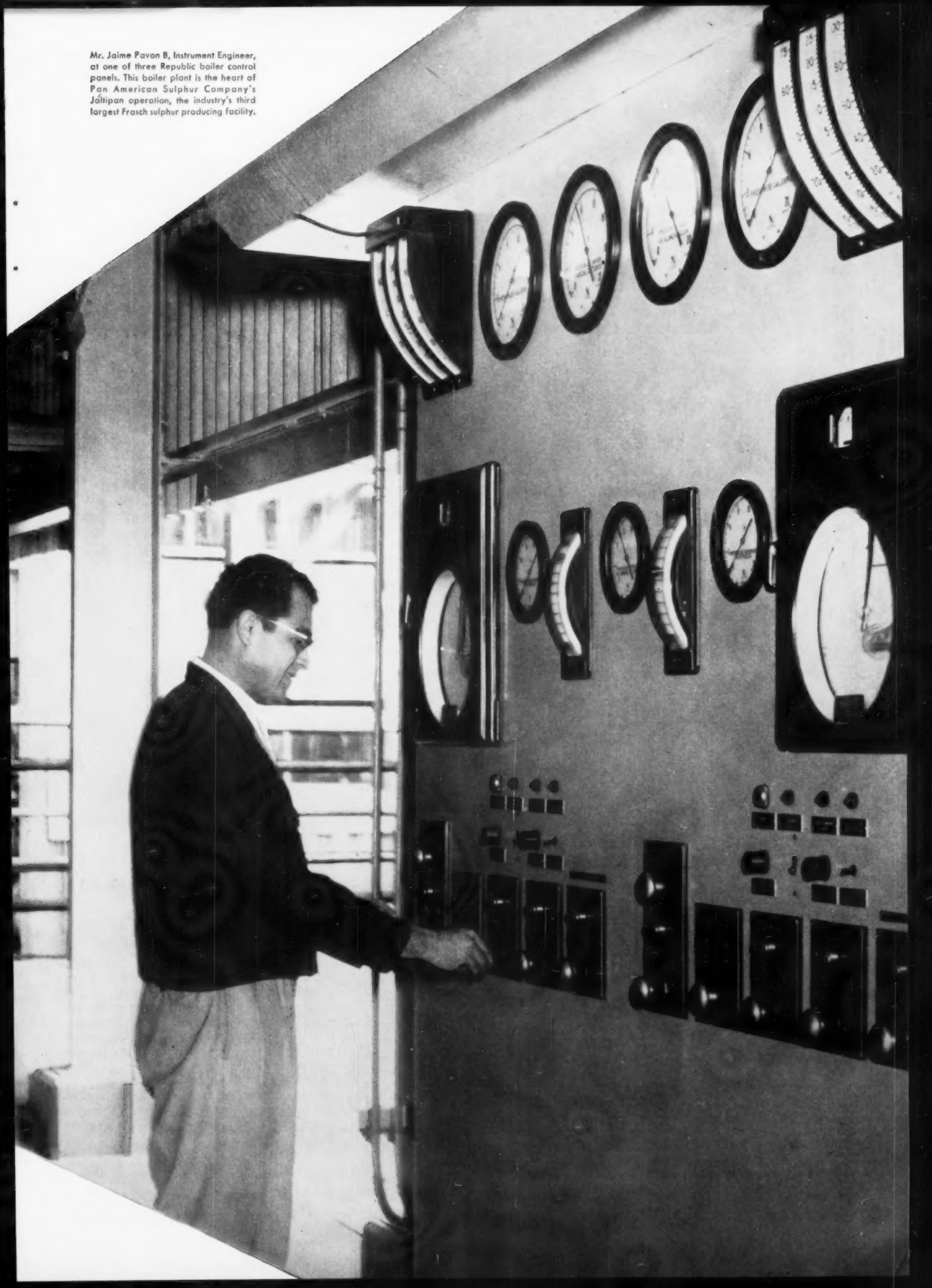
Subsidiary of ROCKWELL MANUFACTURING COMPANY

2240 DIVERSEY PARKWAY – CHICAGO 47, ILLINOIS
IN CANADA: REPUBLIC FLOW METERS CANADA, LTD.
Toronto, Montreal, Vancouver

Manufacturers of electronic and pneumatic instrument and control systems for utility, process and industrial applications.



PAN AMERICAN SULPHUR CO.
President: Mr. Harry C. Webb
Design engineering & construction: Brown & Root, Inc.
Instruments, combustion and feedwater controls: Republic Flow Meters Company, Chicago



Mr. Jaime Pavon B, Instrument Engineer, at one of three Republic boiler control panels. This boiler plant is the heart of Pan American Sulphur Company's Jáltipan operation, the industry's third largest Frasch sulphur producing facility.

Looking for cost leaks? Look at your steam traps

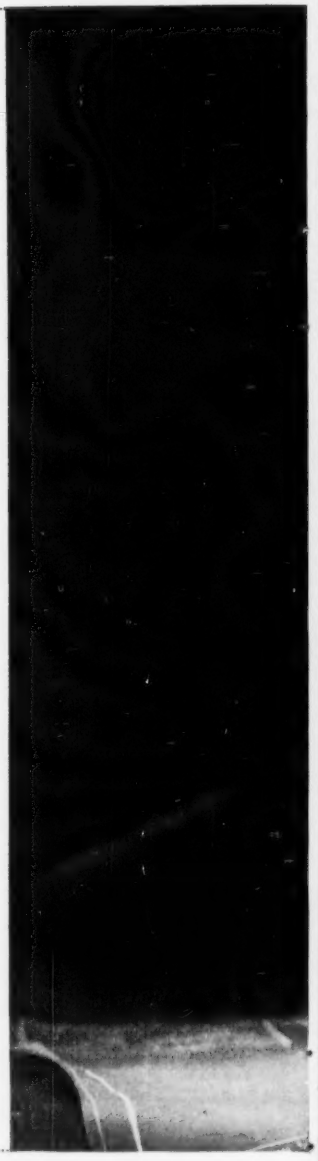
Engineering approach to steam trapping can save thousands a year on costs of fuel, trap maintenance, process cycle time, and uniformity of product quality

Plant and process engineers all across industry have found that Sarco *Production-Planned* steam trapping can pare operating costs by thousands of dollars a year.

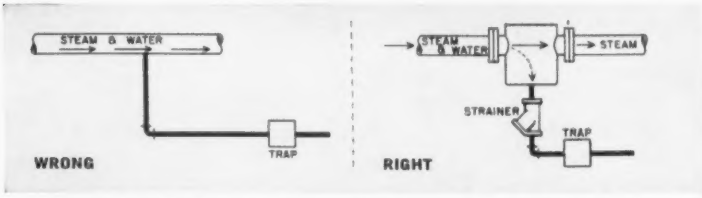
Production-Planned steam trapping is an engineering approach to the problem of getting full design values of heat transfer from steam using equipment. Scores of case histories show that it can make substantial savings and improve processing efficiency. At the same time, costly trap maintenance can be greatly reduced.

In Sarco *Production-Planned* steam trapping, traps are matched to the job by *type* as well as size. They are properly placed, correctly installed. And, to keep down maintenance and replacement costs, every trap is top-quality.

It may pay you well to take this engineer's-eye view of *your* steam trapping. And why not have a Sarco representative look over your system with you? His suggestions will be completely objective because Sarco—and only Sarco—makes a steam trap for every basic requirement. Quality? Recognized everywhere for half a century.



Production-planned systems make best use of traps



As the two illustrations above show, correct application of steam traps is as necessary as using the right trap. In the hook-up on the left, the lack of a condensate collection point plus the long leg to the trap will result in condensate's flowing past the drain point, possibly causing water hammer. The correct way to install the trap is shown at right, placed close to the drain point. A *strainer* should be placed before *any* trap to prevent entrance of scale or other foreign matter into the trap.

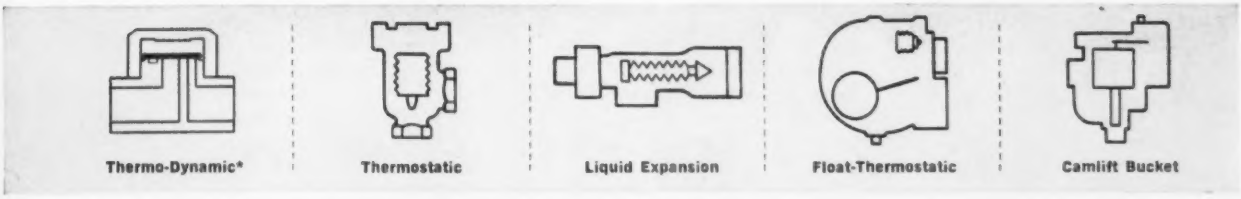
This is just one example of the way your Sarco representative can help you plan your steam system for maximum production.

Traps must be matched to job for best system performance

No single type of steam trap will perform well in all applications. Each type has a range of applications for which it is best suited. For optimum efficiency these differences must be taken into account; traps must be chosen for their operating principles as well as their size and pressure rating.

Sarco can give you impartial help in selecting traps because only Sarco makes the five basic types. With Sarco, it's simple —one source, one responsibility, for all your trapping needs.

Only Sarco makes these five basic types of steam traps



5579

Take these two steps to Production-Planned steam trapping:

(1) Write today for Sarco literature; (2) Talk with your Sarco representative. He can help you check your trapping requirements, and he has—or will quickly get—the right answer to any unusual trapping problem.

*T.M.U. Pat. No. 2,817,353.

SARCO
COMPANY, INC.
635 Madison Ave., New York 22, N. Y.

STEAM TRAPPING • AIR VENTING • TEMPERATURE CONTROLS • HEATING SPECIALTIES

Ford shifts

to coal for low-cost steam

Coal proves economical and easily available for steam generation at Ford's Louisville plant

Assembly Plant #2, Ford Division—Ford Motor Company, Louisville, Ky., was constructed in 1954. Because of the importance of steam for process work and heating, Ford's engineering department—working with the consulting firm of Albert Kahn Associated Architects and Engineers, of Detroit—conducted a fuel survey before the power house was designed. Object: to find an economical and efficient fuel.

Result: *coal* is used because of its *continuous* plentiful supply and advantageous price. Today this advanced coal-burning installation produces a reliable supply of low-cost steam. Only routine maintenance has been required and the cleanliness and general efficiency of this steam plant are considered among the outstanding features of its operation.

Facts you should know about coal

You'll find that bituminous coal is not only the lowest-cost fuel in most industrial areas, as in the case of Ford's Louisville plant, but up-to-date coal burning equipment can give you 15% to 50% more steam per dollar. Today's automatic equipment can pare labor costs and eliminate smoke problems. And vast coal reserves plus mechanized production methods mean a constantly plentiful supply of coal at stable prices.

Technical advisory service

To help you with industrial fuel problems, the Bituminous Coal Institute offers a free technical advisory service. We welcome the opportunity to work with you, your consulting engineers and architects. If you are concerned with steam costs, write to the address below. Or send for our case history booklet, complete with data sheets. You'll find it informative.

Consult an engineering firm

If you are remodeling or building new heating or power facilities, it will pay you to consult a qualified engineering firm. Such concerns—familiar with the latest in fuel costs and equipment—can effect great savings for you in efficiency and fuel economy over the years.

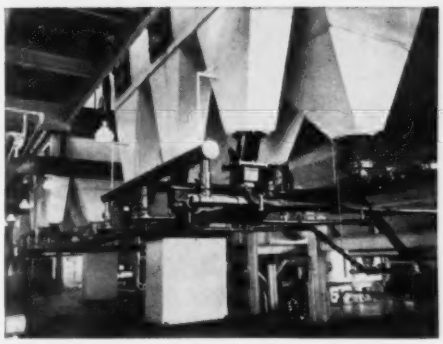
BITUMINOUS COAL INSTITUTE

Dept. P-06, Southern Building, Washington 5, D.C.

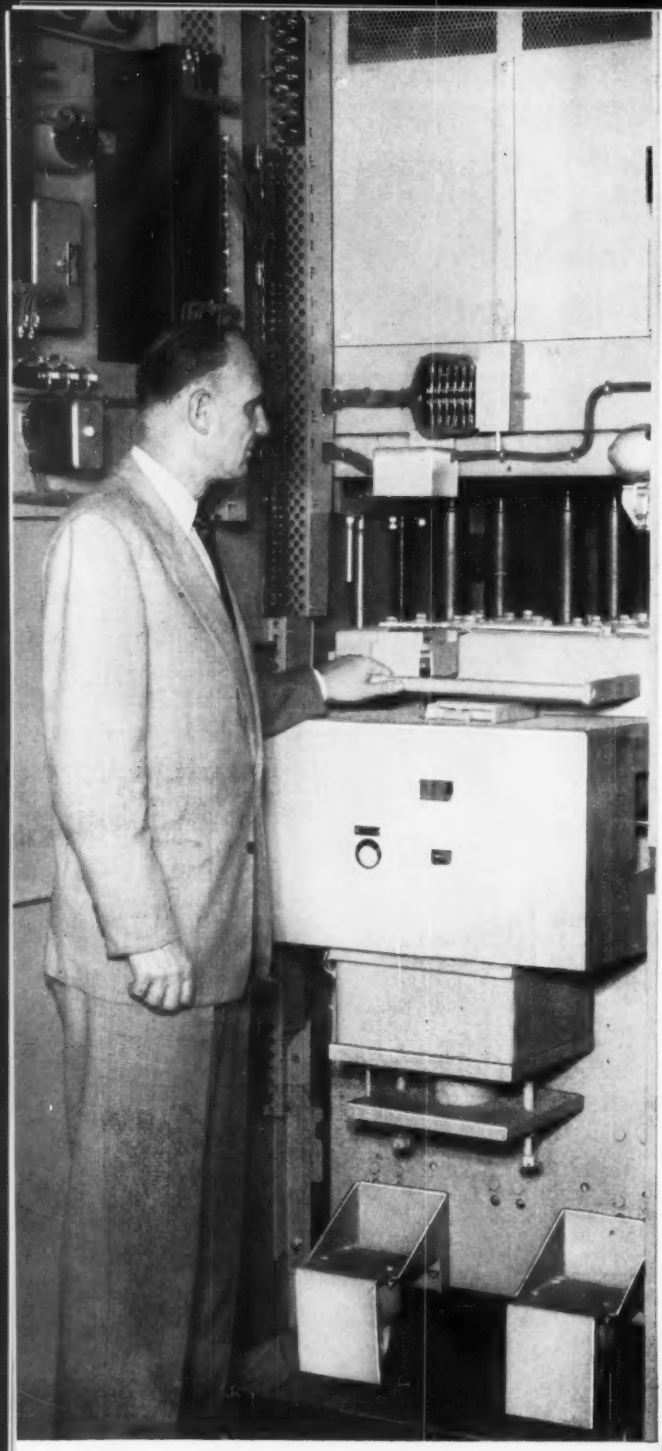
Firing aisle, shows Boiler #1 in right foreground. This is 60,000 lb/hr unit, using a two unit spreader stoker; Boilers #2 and #3 have capacity of 120,000 lb/hr and use four feeders. All three boilers are by Wickes Boiler Co., Type R, operating at 125 psi, 350 degrees F, fired by American Engineering "Perfect Spread" stokers.

Showing National Car Shaker being used to expedite emptying of cars. Dustless ash removal system in background.

Beaumont Birch Steam Vacuum System draws ashes through pipes to outside ash silo for removal. View is at basement level, below boiler room floor. Coal handling system also by Beaumont Birch Co.



Mechanical dust collectors are by Prat-Daniel Corp. Fly ash handling system removes ash from collectors and boiler passes.



SAFETY YOU CAN SEE

With "visual break" design of circuit breakers used in G-E Metal-clad Switchgear

The man who operates General Electric Metal-clad Switchgear doesn't have to guess whether breakers are completely disconnected—he can ***actually see*** when primary disconnects are parted.

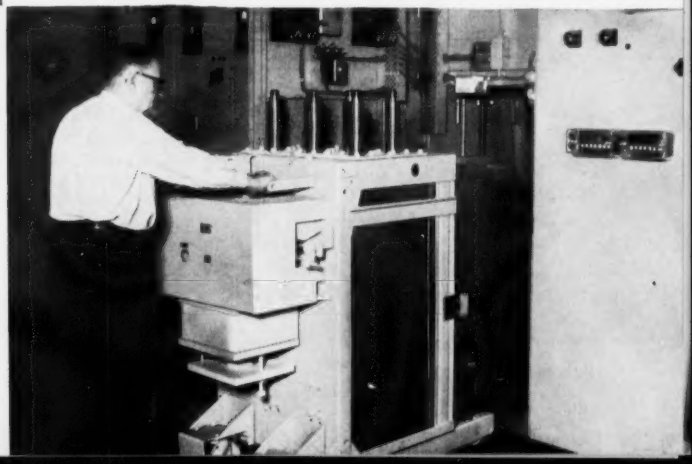
This tangible contribution to safety is made possible by General Electric's vertical-lift principle of operation. Because of vertical-lift, General Electric Metal-clad Switchgear provides "visual-break" safety for operators, plant and equipment.

Further safety is provided by positive interlocks which prevent raising or lowering the breaker unless it is open, and by shutters which automatically shield stationary contacts as soon as the disconnects part.

In addition to "visual-break," General Electric's vertical-lift operation gives you:

- minimized danger of breaker tip-over because of a lower center of gravity
- protection against non-functional hazards because arc chutes and mechanism are covered
- reduced replacement work and maintenance because contacts are protected from falling arc products which cause corrosion and pitting.

For details about the many other advantages of Metal-clad Switchgear, contact your nearest G-E Apparatus Sales Office. General Electric Co., Schenectady, N. Y. 511-29



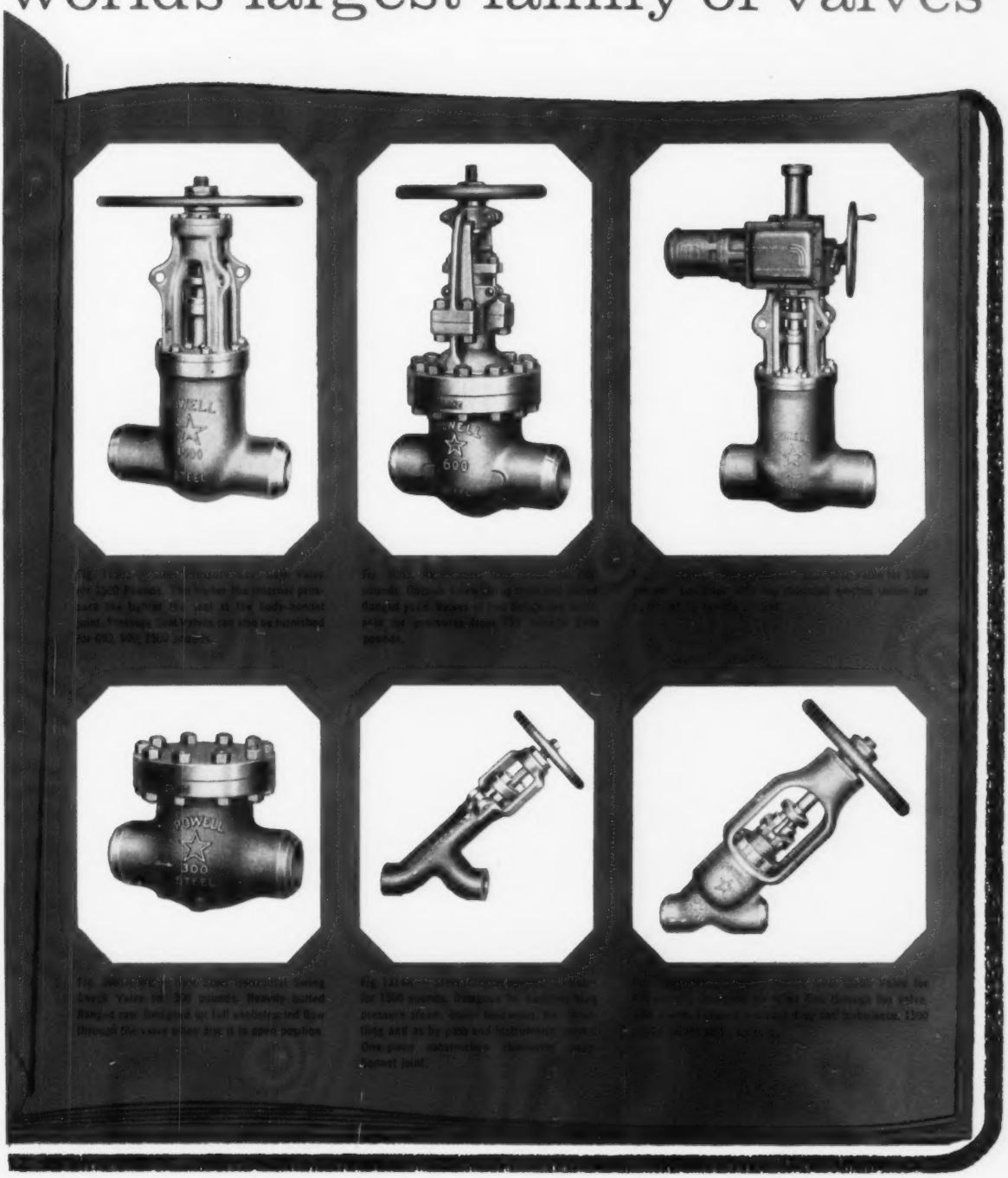
"VISUAL-BREAK" OPERATION greatly simplifies breaker handling during inspection and maintenance. Operators can see when primary disconnects are parted—for safe breaker removal. Breaker's lower center of gravity minimizes the danger of breaker tip-over.

Progress Is Our Most Important Product

GENERAL ELECTRIC

POWELL

world's largest family of valves*



* and in this family there's a valve for every flow control requirement—for handling water, oil, gas, air, steam and corrosive fluids—available in the most required sizes and types. If your local distributor can't supply you, or if you need specially engineered valves for unusual conditions, write

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**

announcing

the most durably engineered turbine type pump yet built . . .

the NEW SCHAUB

POWER PLANT Boiler Feed Pump

TWO-STAGE CENTER MOUNTED
1750 RPM
CAPACITIES to 150 GPM
PRESSURES to 300 PSI

Exclusive

DuraHard®
Electrolized Impellers

A super-hard (1100 Brinnel) "skin" of dense, non-magnetic alloy resists wear, corrosion and erosion. Will not chip, peel or spall. When, or if it eventually wears through, the base metal in its original dimension still has normal service expectancy! Electrolizing also relieves impeller of stresses set up during forming and machining . . . increases impeller life up to 300%.

Now—Get ALL the Advantages of a Turbine Pump —WITH TWICE THE PUMP LIFE!

- **Improved head range and NPSH characteristic of turbine pumps.**
- **Exclusive, super-hardened, triple-life impellers.**
- **New "over-strength" case, shafting and bearings.**
- **Less maintenance, easier servicing.**

Now, for the first time, you can specify or design a boiler feed system offering the advantages and better head characteristics of the turbine pump—*and get maximum pump life, too!*

The new Schaub Power Plant Pumps are "over-strength" in all components. Double-row, pre-lubricated ball bearings are oversize for a wider margin of safety. Newly improved Schaub Flexi-matic Seals permanently end packing problems, scored shafts, lubrication wash-out and seal leaks. Heavy-duty housing and bearing arms keep pumps "in line" and prevent warpage. Low stuffing box pressure doubles shaft seal life.

In short, we believe that in Schaub Power Plant Pumps you now have available to you the most trouble-free turbine pump ever built! Even its minimum maintenance needs have been made easier, quicker . . . and inexpensive.

Schaub Power Plant Pumps are one more good reason for specifying Schaub Boiler Feed Systems. *It will also pay you to specify them for individual pumps and replacements.*

WRITE FOR NEW BULLETIN No. 65 ● Get the full facts on this new major break-through in turbine pump design. Technical data, pump "lore", specifications, dimensions and capacity ratings. A must for consulting and power engineers.

FRED H. SCHAUB ENGINEERING COMPANY
2103 S. Marshall Boulevard, Chicago 23, Illinois

STEEL FORGINGS by MESTA

for HIGH PRESSURE and HIGH TEMPERATURE PIPING

custom made to your mechanical and metallurgical specifications

Y's

TEES

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VALVE BODIES

LATERALS

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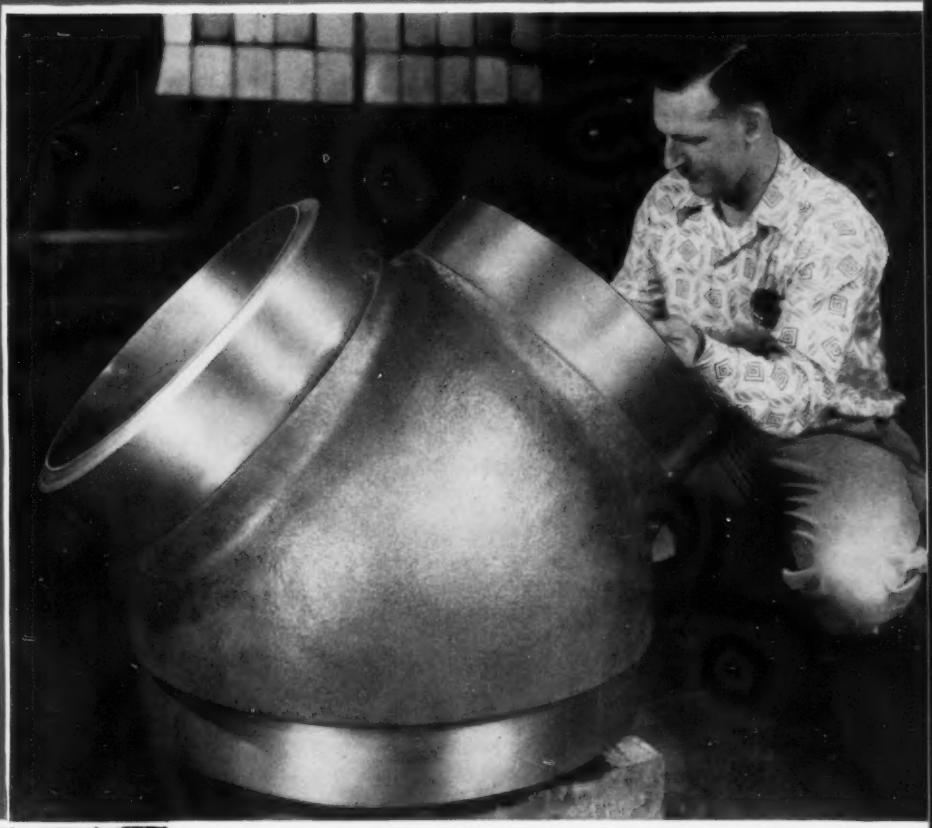
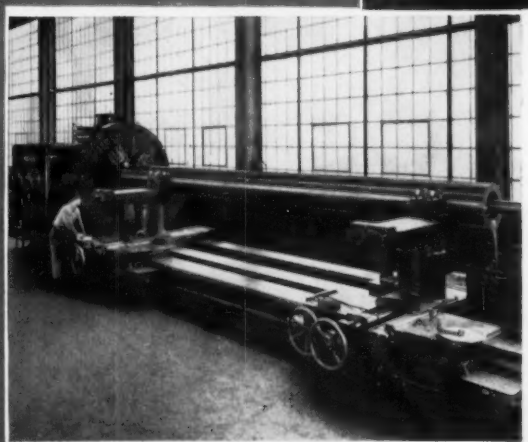
ELLS





Turning and Boring High Pressure — High Temperature Pipe on a MESTA 100" HEAVY DUTY LATHE in one of the Mesta Machine Shops.

Chrome Molybdenum Alloy Steel Y's forged, machined, rigidly inspected and tested to comply with customer and code specifications. Mesta Forged Fittings and Pipe provide confident service in High Pressure and High Temperature Piping Systems.

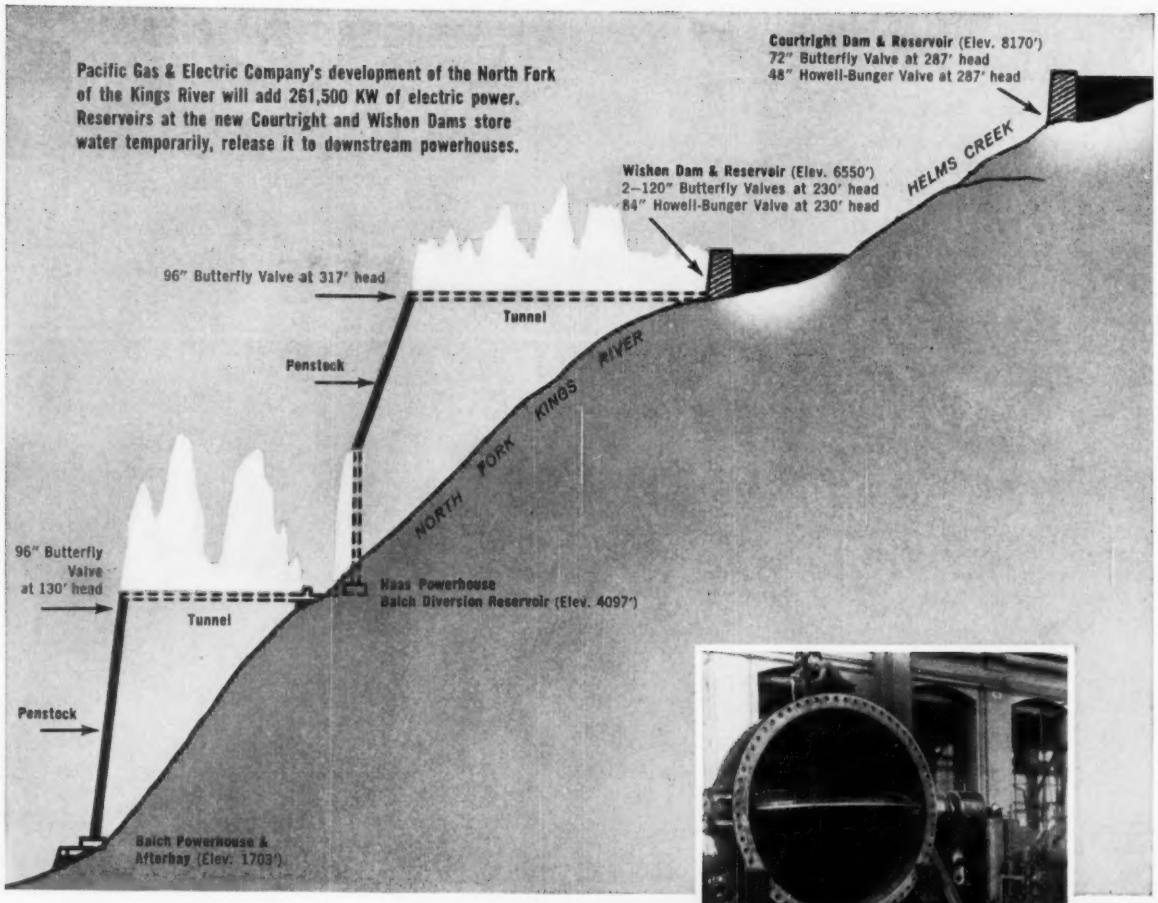
MESTA FACILITIES *for Forged Steel Piping*

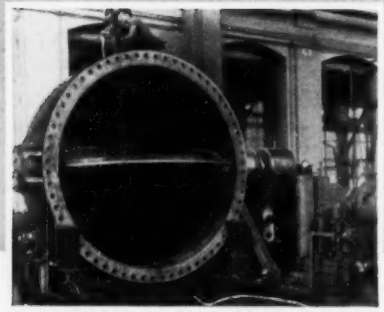
Electric Steel and Open Hearth Furnaces
Forging Presses • Heavy Duty Machine Tools
Chemical • Metallurgical • Physical Laboratories
Complete Testing Equipment

ROLLING MILLS • ROLLS • FORGINGS • HEAVY DUTY TOOLS

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA


Pacific Gas & Electric Company's development of the North Fork of the Kings River will add 261,500 KW of electric power. Reservoirs at the new Courtright and Wishon Dams store water temporarily, release it to downstream powerhouses.
Courtright Dam & Reservoir (Elev. 8170')
72" Butterfly Valve at 287' head
48" Howell-Bunger Valve at 287' head
HELMS CREEK
Wishon Dam & Reservoir (Elev. 6550')
2–120" Butterfly Valves at 230' head
84" Howell-Bunger Valve at 230' head
96" Butterfly Valve at 317' head
Tunnel
Penstock
NORTH FORK KINGS RIVER
96" Butterfly Valve at 130' head
Haas Powerhouse
Balch Diversion Reservoir (Elev. 4097')
Tunnel
Penstock
Balch Powerhouse & Afterbay (Elev. 1703')



During shop tests, the 96-inch valve for Haas tunnel demonstrates the streamlined construction of SMS welded steel plate discs. This reduces head loss and turbulence to a minimum.

Kings River Project installs SMS valves

Five SMS Butterfly Valves and two SMS Howell-Bunger Valves are being installed by Pacific Gas & Electric Company on its Kings River hydropower project in the Sierra and Sequoia National Forests. They will control the flow of water from upstream reservoirs to the powerhouses in this $80 million system.

Seals on SMS Butterfly Valves cut leakage to a minimum. Disc and body seals are adjustable from either inside or outside, as specified. Specially-developed SMS trunnion seals are essentially drop-tight. Welded discs and housings assure freedom from the defects of cast materials, and permit more economical construction.

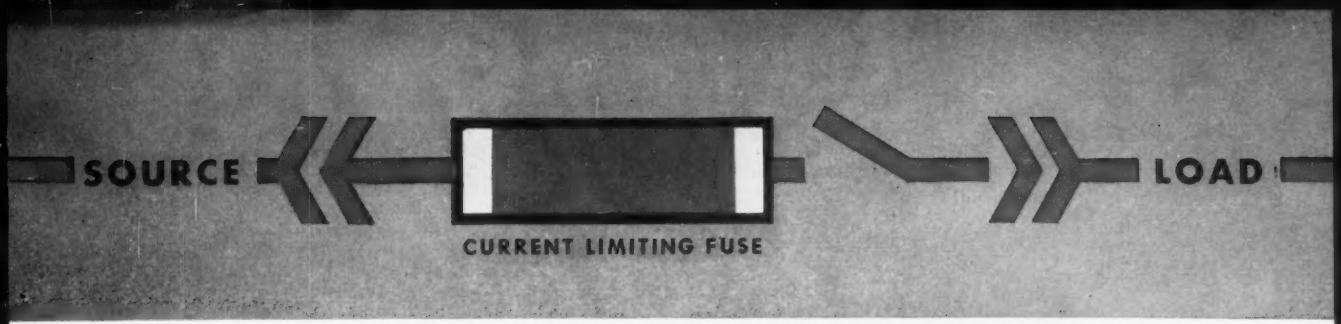
SMS Butterfly Valves have been designed and built in diameters up to 18 feet, and for service with operating heads up to 750 feet. To obtain information on SMS hydraulic turbines, valves and other accessories, write to S. Morgan Smith Company, York, Penna.

One of the 120-inch Wishon Reservoir valves on the SMS assembly floor shows adjustable seals on the discs and recess for the renewable seal ring within the body.

S. MORGAN SMITH — HYDRODYNAMICS — More Power To . . .

AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED, TORONTO

Rotovalves • Ball Valves • R-S Butterfly Valves • Free-Discharge Valves • Liquid Heaters • Pumps • Hydraulic Turbines & Accessories



CURRENT LIMITING FUSE ON *SOURCE* SIDE OF SWITCH FOR SHORT-CIRCUIT PROTECTION

Improved protection with

General Electric ROLLOUT

Switch and Fuse Equipment

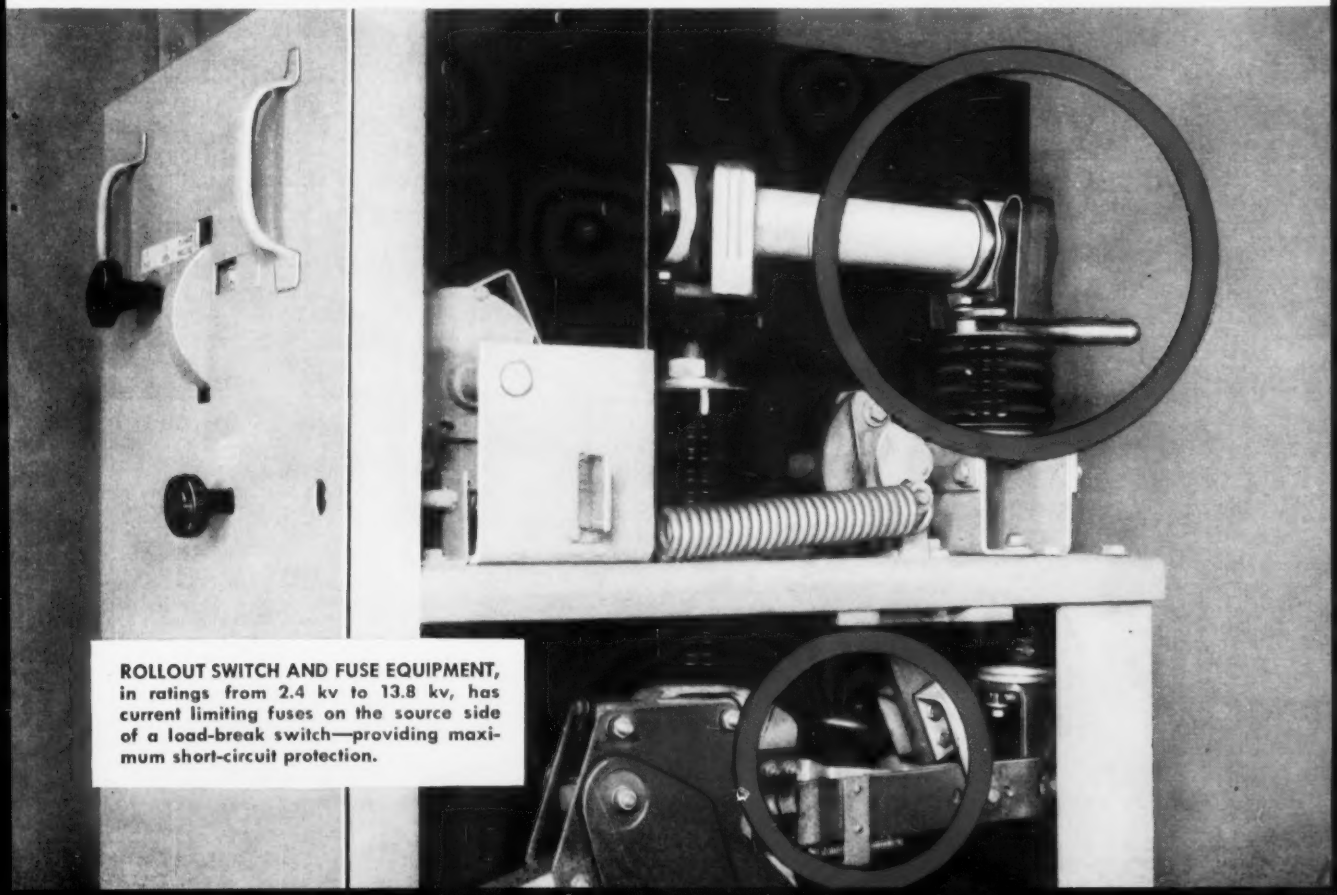
You get improved short-circuit protection with General Electric's new Rollout Switch and Fuse Equipment—because current limiting fuses are placed on the *source* side of a load-break switch.

You also get greater safety, easier maintenance and inspection, and installation versatility—with the new equipment's rollout feature.

Call your nearest General Electric Apparatus Sales Office for more information or write for Bulletin GEA-6623, General Electric Company, Section J-514-3, Schenectady, New York.

Progress Is Our Most Important Product

GENERAL ELECTRIC



ROLLOUT SWITCH AND FUSE EQUIPMENT, in ratings from 2.4 kv to 13.8 kv, has current limiting fuses on the source side of a load-break switch—providing maximum short-circuit protection.

This is the latest in precise, adjustable speed control for draft fans and BF pumps!

E-M standard construction for most indoor applications.

REDUCE BOILER OPERATION COSTS

with one of the four new E-M ADJUSTABLE SPEED MAGNETIC DRIVES

- **More power in less space**
- **Simpler installation**
- **Better, quieter cooling**
- **Lower maintenance**

E-M Magnetic Drives help you reduce costs of auxiliary drive power and maintenance. Here's how:

LOWER POWER COSTS by eliminating need for wasteful throttling of boiler feedwater pumps and draft fans. Magnetic Drives *control speed* for efficient operation of auxiliaries.

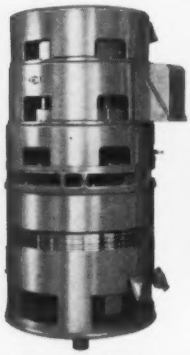
MINIMIZE FAN EROSION by operating fans at speeds to fit boiler combustion demands.

HAVE FAST RESPONSE to improve combustion and cut down thermal losses.

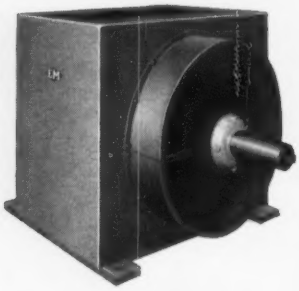
GIVE ACCURATE SPEED CONTROL. "Regutron" Control is responsive to *speed* of driven equipment regardless of changes in operating conditions. "Magnetic action" gives ±½% sensitivity. Anti-hunt and damping circuits assure stable operation.

OFFER BROAD SPEED RANGE. A large number of speed steps gives virtually stepless speed control . . . lets you select and keep exact speed.

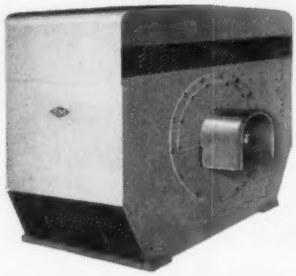
Write E-M for literature, or call your nearby E-M Field Engineer. He'll be glad to tell you first-hand all about the new developments in E-M Magnetic Drives.



Vertical E-M Magnetic Drive and Motor.



Top air discharge type for larger high speed ratings. Heat can be ducted away.



Weather-protected outdoor design. Screened intakes at feet, discharge near top.

E-M

4400-TPA-2175

ELECTRIC MACHINERY MFG. COMPANY

Minneapolis 13, Minnesota

Specialists in making drives do **EXACTLY WHAT YOU WANT THEM TO**

IN SRE... Zallea expansion joints absorb thermal expansion of reactor core tank and outer tank

The very nature of the Sodium Reactor Experiment, conducted by Atomics International for the AEC, and the method of handling the liquid sodium reactor coolant demand reliability in expansion joints. Because of the operation there can be no compromise in design or quality.

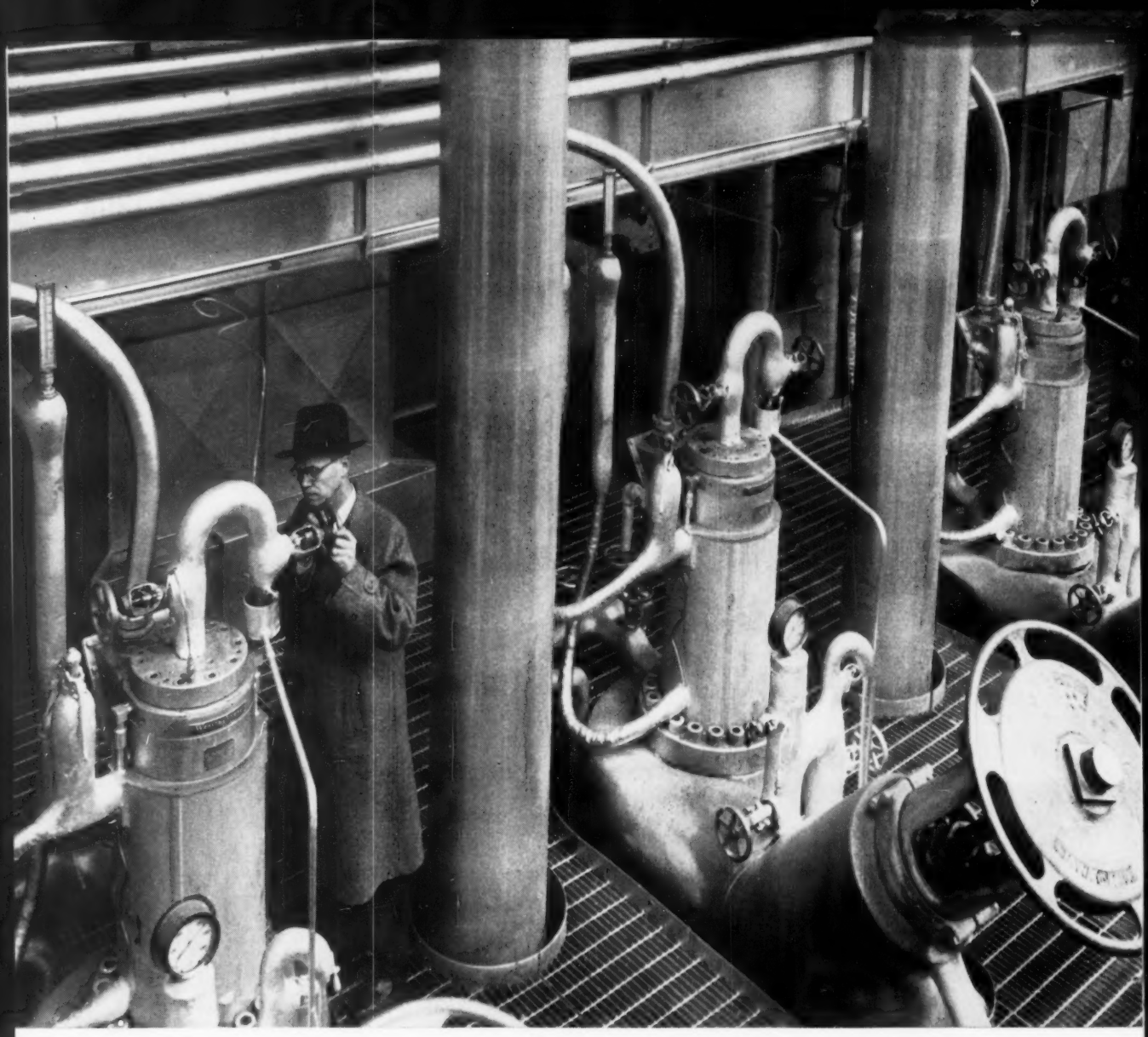
The high temperature SRE uses Zallea Expansion Joints where thermal expansion must be absorbed and where a gas seal must be maintained. An 11-ft. diameter Zallea Expansion Joint at the top of the outer tank absorbs the expansion that results from the temperature increase in these components as the reactor comes up to operating temperature, 960°F. In addition, the expansion joints form a seal for the helium gas and sodium vapor above the sodium pool at the top of the reactor as well as for the helium gas within the outer tank.

In the sodium coolant piping circuit gas seals are effected by means of Zallea Expansion Joints in the region where the pipes leave the reactor cavity and enter the pipe galleries.

Zallea has worked with almost every major engineering and manufacturing firm engaged in atomic, nuclear and missile work—and has provided the large majority of expansion joints for such projects. As a result, we have accumulated a store of expansion joint engineering data and manufacturing skills that cannot be equalled. Whenever expansion is involved in piping systems, reactors, tanks—whatever the application—let our engineers work with you. We already have the answer to many of the difficulties you will encounter. And we welcome the chance of tackling your problem.

Zallea
expansion joints

ZALLEA BROTHERS, Wilmington 99, Del. • World's largest manufacturer of expansion joints



Westinghouse canned motor-pumps

specified for KP&L outdoor installation

The Kansas Power and Light Company recently increased the capacity of its Tecumseh Station with the addition of a 75,000-kw outdoor unit. This new addition, the most efficient in the plant, will operate day and night as the base load unit. To insure reliability, Westinghouse canned motor-pumps were specified for the Combustion Engineering Inc. controlled circulation boiler.

Westinghouse pumps were selected because: they have been proven for long-term continuous operation in many other installations; the zero-leakage feature eliminates injection water sealing. Two pumps provide the required boiler water circulation to deliver 635,000 pounds of 1000°F steam at 1800 psi. A third Westinghouse pump is kept on hot standby. All three are rated at 4070 gpm, 1958 psi, 615°F.

For further information on the tested and proven Westinghouse canned motor-pumps, contact your Westinghouse sales representative, or write: Westinghouse Electric Corporation, Atomic Equipment Dept., P.O. Box 217, Cheswick, Penna.

J-57019

YOU CAN BE SURE...IF IT'S Westinghouse

PHILIP W SWAIN
1889-1958

On April 27, Phil Swain died suddenly at his home in Riverside, Conn. Associated with POWER for more than 36 years, he had been its chief editor from January 1934 to September 1954, when he retired and became consulting editor.

Those of us who saw and talked with Phil recently still find it difficult to realize he is gone. Vigorous, youthful in outlook, bursting with plans for the future, he was obviously finding retirement just a new phase in a life that was continuously exciting and rewarding. At that full tide he left us, and when we who knew and loved him recover from the shock of sudden loss, we may come to feel that this was as it should be—no lingering illness, no slow loss of the zest for life.

Because, above all, Phil Swain was zestful. He literally seethed with ideas and enthusiasm—not only for his challenging work as editor but also for the many interests and hobbies that made his life a full and rounded one and that made him an endlessly fascinating friend and companion.

By POWER readers, Phil will be remembered as the second of its two great editors. In 1921, Fred Low, editor from 1888 to 1930, sought a man who could put engineering facts into plain talk. The man he found was Phil Swain, and plain talk was a ruling passion of Phil's throughout an editorial career that saw him move from assistant, to associate, to managing, and finally to chief editor.

Born August 26, 1889, in Westerville, Ohio and reared in New England, Phil came to POWER with degrees from Syracuse and Yale and a colorful background as machinist, college teacher, artillery officer, and field engineer.

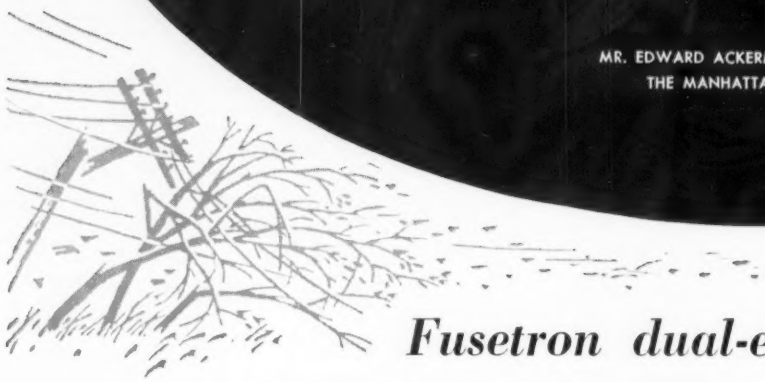
With his own blend of scientific insight and finger-tip mechanical sense, Swain carried forward the Fred Low tradition of practical service in a period of rapid technological change that culminated in wresting energy from the atom.

And, more than anything else, this last development revealed the qualities that made Phil Swain a great editor. He had the vision to see the atom's peaceful potential at a time when the chain reaction was still only an untested idea and he had the courage to forecast its possibilities in a 1940 article that was the first of its kind to appear in the industrial press. After Hiroshima, and the Bikini tests at which he represented McGraw-Hill, Phil used his rare gift for lucid analysis of complex technical matters to clarify for engineers and the general public the true meaning of the bomb and the power possibilities of the fission and fusion processes. In the pages of POWER and in dozens of speeches, he crusaded for straight thinking on these great issues of our times.

By his associates on the staff, Phil will be remembered as a uniquely stimulating leader. Gifted with intuition for selecting engineers with the spark of journalistic ability, Phil was equally gifted in fanning that spark. A teacher of rare skill, he was never too busy to roll up his sleeves and show a young editor exactly how to follow the Swain philosophy of engineering journalism: Know what you're talking about, say it simply and clearly, keep it warm and human.

In the publishing world, in the engineering profession, in his community, Phil Swain's leadership was recognized in manifold ways. He was a member of Sigma Xi and Tau Beta Pi, a Fellow of the American Society of Mechanical Engineers, an honorary Doctor of Engineering (Case Institute). In the memories of his many friends he will live as a man who found the world endlessly interesting and challenging, who lived to the full peak of his powers and, because of that, was a man continuously stimulating and rewarding to know.

MR. EDWARD ACKERMAN
THE MANHATTAN SHIRT CO.



Fusetron dual-element fuses protected 150 motors against burnout when a hurricane single phased our primary line

MR. EDWARD ACKERMAN
CHIEF ELECTRICIAN-THE MANHATTAN SHIRT CO.
PATERSON, NEW JERSEY

558

Mr. Ackerman continues . . .

"One afternoon a hurricane struck and single phased the line feeding our plant.

"At the time, all 150 of our sewing machines were in operation. No one suspected the motors were running single phase. Our first warning came when the machines started shutting down through the plant as Fusetron fuses began blowing to protect the motors.

"I had no idea in what condition we would find the motors. It was certainly a relief when we checked and did not find one damaged sewing machine motor. Around 300 Fusetron fuses had blown to protect them.

"You can imagine how costly it would have been to repair or replace these ½ hp., 3 phase, 220 volt motors — and our plant would have been out of business while this work was being done. So we think we paid a very small price when our only expense was replacing the 3-2/10 ampere Fusetron fuses.

"Since this experience, our seven other plants have been informed of the above incident, and it has been suggested to them, that they protect all sewing machine motors with Fusetron dual-element fuses."

Why Fusetron fuses provide safest, simplest way to prevent damage from single phasing.

When single phasing occurs, the current in the remaining phase increases about 100%. (Theoretically 73% but change in efficiency and power factor makes it about 100%.

This 100% overload on Fusetron fuses of motor-running protection size opens them and shuts down the motor.

Such dependable protection against motor burnouts from single phasing has never before been available.

You too, can get maximum electrical protection and save money by installing Fusetron dual-element fuses throughout the plant

With rare exceptions on commercial and industrial installations — ordinary fuses and circuit breakers protect only against short-circuits — but Fusetron dual-element fuses provide 10 point protection.

FOR LOADS ABOVE 600 AMPS. — USE BUSS HI-CAP FUSES TO COORDINATE YOUR ELECTRICAL CIRCUITS.

On 600 volts or less, BUSS Hi-Cap fuses have interrupting capacity sufficient to handle any fault current regardless of system growth.

They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuits of origin.

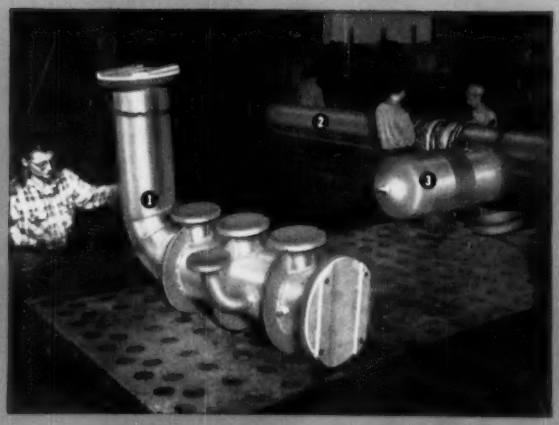
FOR MORE INFORMATION ASK FOR BULLETIN FIS ON FUSETRON DUAL-ELEMENT FUSES — BULLETIN HCS ON BUSS HI-CAP FUSES.

BUSSMANN MFG. DIVISION
McGraw-Edison Co.
University at Jefferson, St. Louis 7, Mo.

Play Safe! install FUSETRON dual-element FUSES and BUSS Hi-Cap FUSES throughout entire Electrical System!

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

ALL IN A DAY'S WORK at *Pittsburgh Piping*



These three jobs are typical of the wide variety of custom piping work which we do for the power and process industries. In the background of the photo welders are shown making the heli-arc root pass on 18" O.D., 3.875" wall, chrome-moly main steam piping. In the foreground, ready for final inspection, is a 12" header for a process operation, fabricated of ⅜" aluminum alloy. The pressure vessel, of austenitic steel, is one of many we produce for atomic energy application. The manufacturing of this type of piping requires specialized facilities . . . for engineering, fabricating, testing, assembly, and erection. We have those facilities. Use them on your piping jobs.

Promoting Progress ***IN POWER AND PROCESS PIPING***

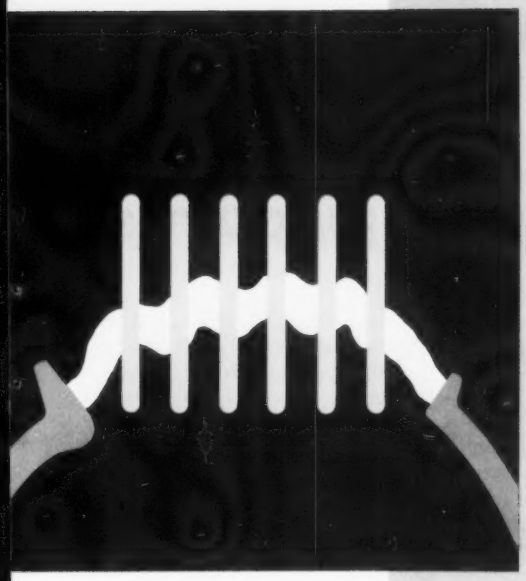
Pittsburgh Piping **AND EQUIPMENT COMPANY**
158 49th Street—Pittsburgh, Pa.

Canada: **CANADIAN PITTSBURGH PIPING, LTD.,** 68 YONGE ST., TORONTO, ONTARIO

Atlanta	*Whitehead Building*	*Cleveland*	*Public Square Building*
Chicago	*Peoples Gas Building*	*New Orleans*	*P. O. Box 74*
	New York	*Woolworth Building*	

a **Power**
special report
June 1958

Electrical Distribution Protection



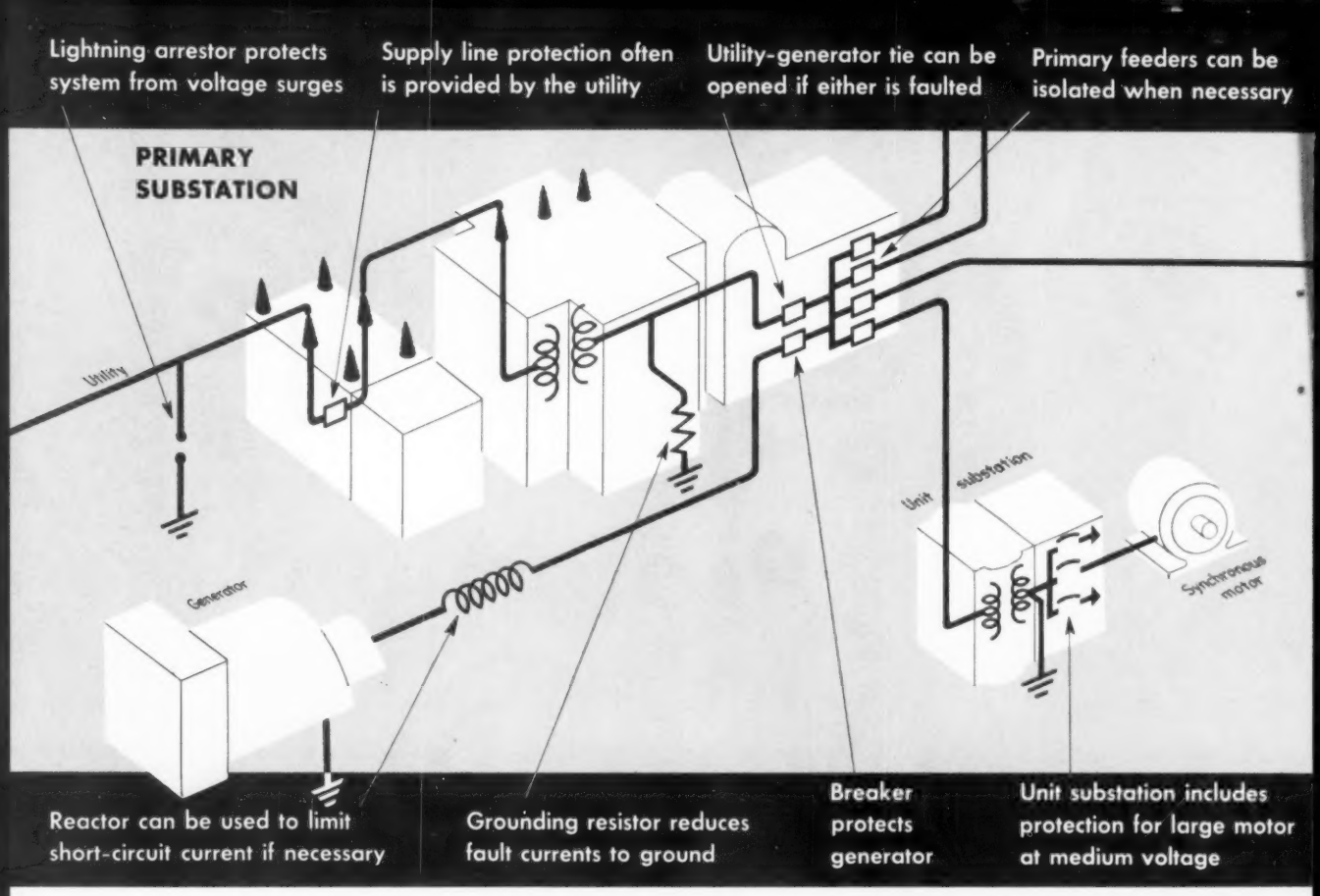
By NORMAN PEACH
Assistant Editor

There is no disputing the fact that without the ready availability of electric power and the skillful distribution and application of this power, the tremendous economic growth we have seen since World War II would not have been possible. However, in looking into many industrial plants we see what is in effect a throttling of the ready flow of electric power. This is not caused by a power shortage, but rather, results from shortsighted planning.

It was this latter fact that prompted our current Power-to-Grow . . . *electrically* editorial program, started in the pages of POWER, September 1956. The editors of POWER launched this continuing PTG series simply to focus attention on the need for better planning for the years ahead.

The importance of protective gear grows in tune with system growth. Sheer growth in load magnitudes is one reason; growth in available short-circuit current is another. In a high-capacity system, circuit breakers, fuses, load interruptors handle normal and abnormal currents with production continuity and safety kept in mind. The significant upsurge in available short-circuit currents in recent years has made much of our presently installed gear obsolete and hazardous. Yet we still find many plants trying to produce and compete under these handicaps.

In the pages that follow we take a look at a hypothetical distribution system and pinpoint the protection problems it presents. Following this look at systems, there's a section on how to calculate fault current. With the kind and size of the problem set up, we scrutinize the protective equipment available today and how it is best applied.


Lightning arrestor protects system from voltage surges
Supply line protection often is provided by the utility
Utility-generator tie can be opened if either is faulted
Primary feeders can be isolated when necessary
PRIMARY SUBSTATION
Utility
Generator
Unit substation
Synchronous motor
Reactor can be used to limit short-circuit current if necessary
Grounding resistor reduces fault currents to ground
Breaker protects generator
Unit substation includes protection for large motor at medium voltage

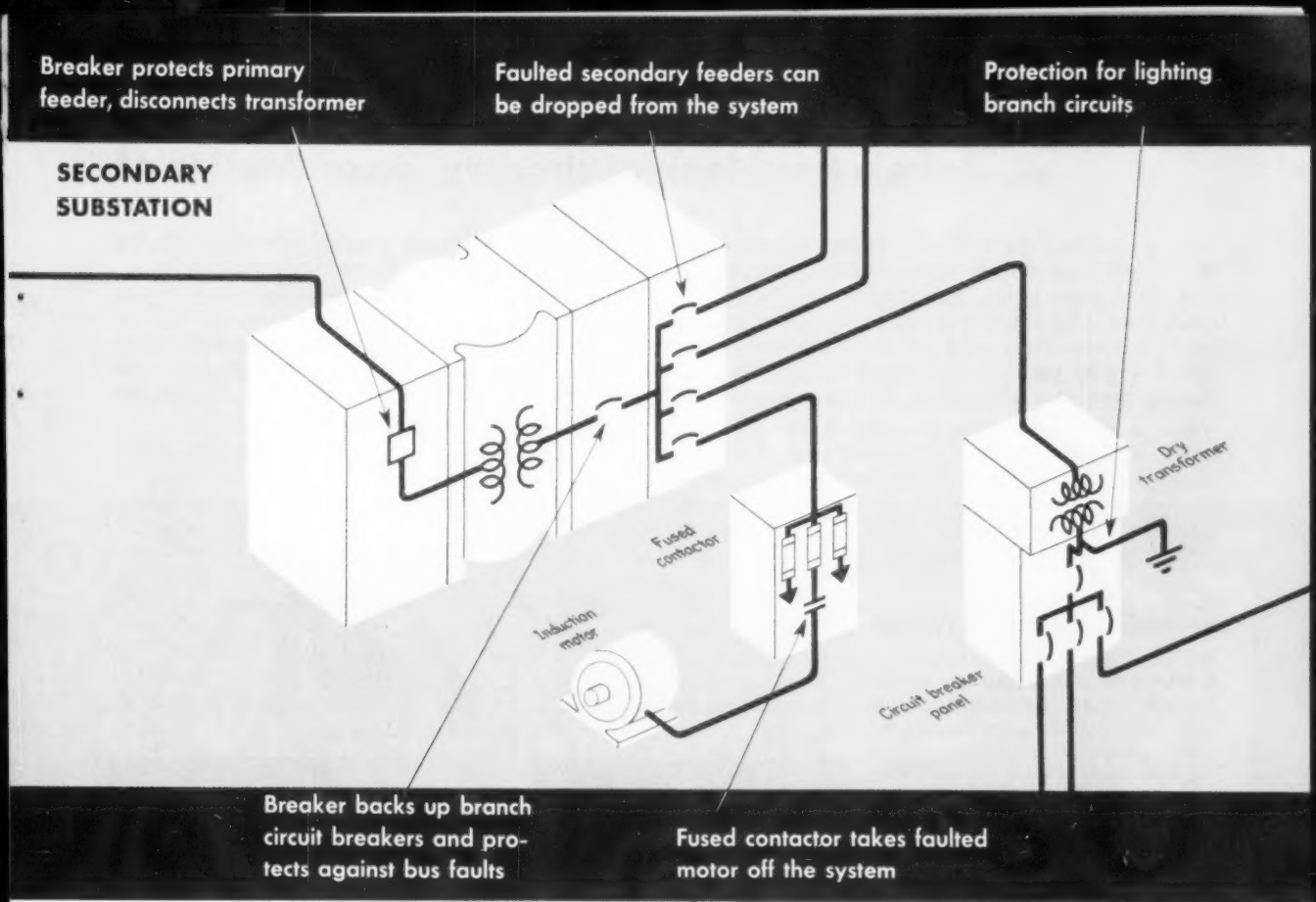
Basic distribution scheme pinpoints

Protection of electrical distribution systems from fault conditions — short circuits, accidental grounds, lightning and switching surges — requires (1) opening circuits rapidly to disconnect fault from rest of system (2) limiting magnitude of system disturbances; that is, short-circuit current, abnormal voltage drop, voltage and current surges. Effectiveness of the first requirement, which is accomplished by circuit breakers and fuses, is a major factor in the second. Magnitude of system disturbances is also kept down by proper use of reactors, grounding devices, lightning arrestors.

Loss of production, damage to equipment and fatal injuries can result from inadequate protection. Your electrical system may well have outgrown its protectors without your being aware of it. Only way to play safe is to make a study of what would happen if a short circuit occurred in any part of your system. Keep this study up to date with changes in your system, such as addition of new equipment. Because serious faults occur infrequently, it's easy to forget what disastrous amounts of energy can be released when they do hit, even in small low-voltage distribution systems. Simplified radial scheme, sketched above, emphasizes areas of distribution system where protection is needed. Each area presents its own set of problems. To plan your protection scheme you must have a firm knowledge of actual plant conditions. For example, a more complicated protective setup is called for if you can't tolerate power interruption; if you can shut down half of your plant for a few hours, your protective plan need not be as elaborate.

Short circuits are main subject of circuit protection. An accidental ground becomes a short circuit on a grounded system, as does the second accidental ground on an ungrounded layout. When short circuit happens, impedance of utilization equipment — motors, ovens, lamps — is bypassed; Ohm's law goes to work with only low impedance of distribution system and power supply. The power supply — utility lines or plant generator — is significant in short-circuit current. If your utility cuts impedance of its lines, short circuits in your plant may double or more in amperage. Without making any changes in your plant, your circuit protectors can become inadequate and dangerous. So your first move is to get together with your utility.

Relaying is an important feature of circuit breakers, p 88. It means the sensing device that causes breakers to operate can be remote from the breaker, and breakers can be interconnected into a complex protective program.


Breaker protects primary feeder, disconnects transformer
Faulted secondary feeders can be dropped from the system
Protection for lighting branch circuits
SECONDARY SUBSTATION
Fused contactor
Induction motor
Dry transformer
Circuit breaker panel
Breaker backs up branch circuit breakers and protects against bus faults
Fused contactor takes faulted motor off the system

areas where protection is needed

Breakers can be made to open and close not only on overcurrent, but to transfer load, connect buses, etc, where required for system performance.

Protectors serve two functions: those nearest the fault (often called *primary* protectors) try to isolate the faulted equipment; those nearer the source have the added job of backing up the primary protectors if they fail by interrupting a larger area of the system. In sketch, above, fault on synchronous motor should be cleared by its unit substation breaker, but if this breaker fails, the primary feeder breaker or fuse will take over.

Breaker at high side of primary transformer protects supply, backs up primary distribution breakers. Often it's not required by utility, and you can get backup protection with a fused switch. Or omit fuses and leave backup to utility if you don't have supply line to protect, or don't use differential relaying for transformer protection. For a high degree of protection, however, use circuit breakers even though they aren't required.

Main transformer breaker, sketch, above, serves as a tie with the generator on the primary bus, and is required wherever there's more than one feed to the bus. Otherwise, its main job is to isolate faults on the primary bus. With single feed it's sometimes omitted in unit substations, but a good idea is to have a main breaker to take care of possible expansion of the system.

Large synchronous motor may operate at 4160 volts where primary voltage is 13.8 kv, secondary 480 volts. Breaker or fused contactor isolates faulted motor from its unit substation; primary feeder breaker disconnects faults in motor's substation and feeder.

Secondary substation, sketch, has breaker in primary for maximum protection. Common practice is to rely on feeder breaker in primary substation. But, if more than one substation is operated off feeder, NEC specifies when individual primary side protection can be omitted (1956 edition, Section 4512). Frequently, fuses are used instead of circuit breakers.

Main breaker between transformer and bus is set to protect the transformer. It may include overload as well as fault protection. Alternate scheme, occasionally used, sets low-voltage feeder breakers so sum of their trip settings approximates protection afforded by main breaker.

Protection beyond secondary substation is usually fitted to particular load. Sketch shows a motor protected by combination of current-limiting fuses and circuit breaker. In some plants, lighting will be 277 volts, with dry transformer giving 120 volts for convenience outlets.

Take a hard look at circuitry, co-ordination of

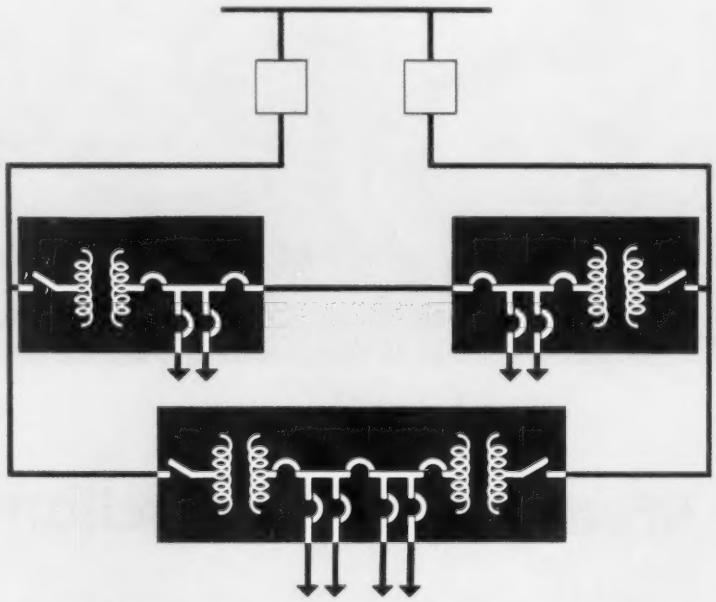
Circuitry available offers different degrees of service continuity with some increase in the complexity of protection. The radial system used in basic diagram, pp 74-75, serves most plants. Secondary selective, primary selective and network systems described below can reduce area of system that is put out of service by a fault. The four basic circuits have many adaptations—some quite complicated.

Co-ordination between protectors should be such that a fault will cause a minimum interruption of service. Referring back to sketch, p 75, a fault on the induction motor should be cleared by the fused contactor near it, without tripping the feeder breaker in the secondary substation. But the main transformer secondary breaker might be loaded close to its tripping point, and a low-current

Secondary selective system

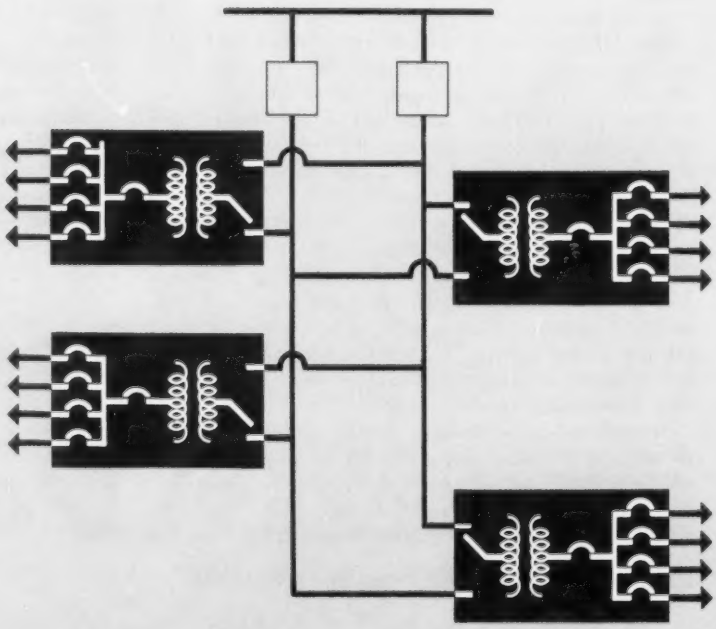
Greater reliability is gained in what is basically a radial system by providing a tie with normally open breaker between secondary buses. Any part of system from source through secondary substation main secondary breakers can fail, yet power can be made available on every secondary bus by opening proper substation main breaker and closing proper tie breaker.

Spot secondary selective arrangement has pairs of single substations side by side (or double-ended substation) with a bus tie. Distributed scheme has substations nearer load with long tie cable, shorter feeders.



Primary selective system

Two primary feeders, each big enough to carry entire load, go to each substation. With proper switching equipment on incoming side, either can be used to supply power. If fault occurs in a primary feeder or transformer, the associated feeder breaker opens and interrupts service to half of the load area. The unfaulted transformers which are then out of service are manually switched to the other feeder to restore service to the loads served from these transformers. If a transformer fault occurs, the faulted transformer and its load are without service until the transformer is repaired or replaced, or until a temporary secondary tie is made.



interruptors to get top reliability from your system

short circuit in the motor might trip it before the protective devices between it and the motor are opened. Although this occasionally occurs in any system, in a well-designed system you can expect it to happen only infrequently. Protectors must be selected to do the right job, opening to clear the circuits for which they are intended.

Simplest form of selectivity is to size protectors large enough so those nearest the fault will open first, regardless of magnitude of fault. Often this isn't adequate, since protectors near source may have to be set too high to protect properly. Selectivity usually is achieved with protectors having time delay. In a properly co-ordinated system, the protective devices should be preselected (as in case of fuses) or field adjusted to operate (1) on minimum current which will permit them to distinguish between fault and load current, and (2) in minimum time to permit selectivity with other devices in series with them.

Protective devices have time-current characteristics peculiar to the design of the protector; that is, the time a protector will pass a given value of current without opening is not identical for all designs of protectors of a particular rating. Manufacturers can supply characteristic curves for their devices, p 95.

To co-ordinate a system:

(1) Determine the different values of minimum and maximum fault current required to permit selection of time-current curves of devices which will co-ordinate. This involves calculation of short-circuit currents, p 80.

(2) Select time and current settings for the adjustable devices. Check performance of the nonadjustable devices to secure a combination that will operate in the sequence necessary to isolate a fault with minimum disturbance to unfaulted parts of the distribution system.

(3) Plot time-current curves for those protectors that are to operate selectively in series. This insures that there will be no overlapping of time-current curves or unnecessarily long operating-time intervals between devices in series. Curves should be plotted on a single sheet of graph paper using a common current scale. Most engineers favor the current scale of lowest voltage range, converting currents of higher voltage ranges by multiplying by the appropriate voltage ratio. The preferred method calls for the curves to be plotted as each circuit is studied, progressing from the protector farthest from the source.

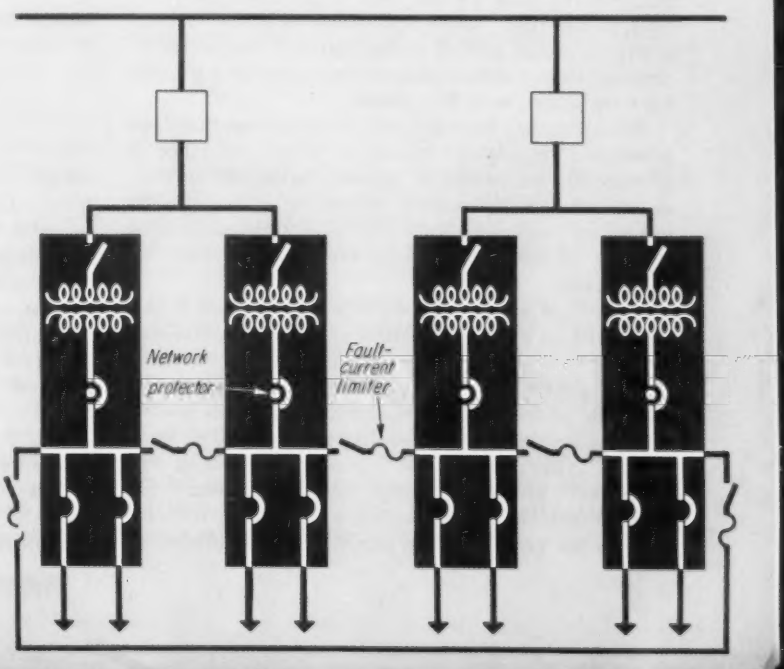
Tripping characteristics of a breaker necessarily tend to form a band, although for high- and intermediate-voltage breakers it can usually be considered to be a line. For molded-case breakers, the band is defined by a lower ampere time value, below which breaker will reset and not trip, and an upper value of maximum time needed for breaker to open circuit for a given current.

Having emphasized importance of selectivity, it's only fair to mention that sometimes engineers suggest an alternate setup for low-voltage circuits which has a lower first cost. When circuit breakers are applied according to this method they are said to be connected in cascade.

In the cascade arrangement, only the breaker closest to the source has adequate interrupting capacity. Those down the line are applied beyond their ratings. They're expected to be backed up by main breaker if heavy short occurs. If there is a heavy short, even beyond last breaker, main breaker may trip out, killing all service. Where cascading is adopted, each breaker should be inspected after tripping on a heavy fault before reclosing. Today, cascading is usually limited to two steps: breaker nearest source has full rating; next from it has one-half interrupting rating needed by maximum available fault current.

Network system

Networks give uninterrupted secondary power even if a primary distribution feeder or secondary substation transformer fails. All secondary substations have their low-voltage sides tied together in a loop or network. High-voltage feeds are set up like those in radial or secondary selective systems. Each transformer secondary feeds into the load network through a network protector, p 93. When load is added anywhere, it's shared by system collectively. When transformer or primary feeder fails, network protector and proper primary breaker trip, disconnecting faulted equipment. Service to load isn't interrupted, other substations share load.



Grounding: aid to protection

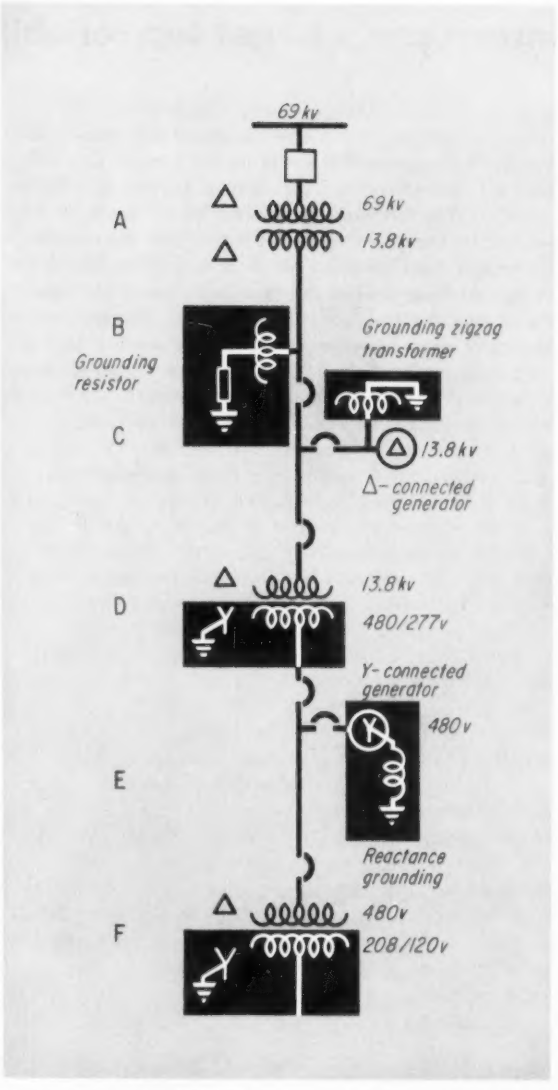
Advocates of system grounding have been gradually prevailing through the years, although some plant engineers, long on experience with ungrounded systems, haven't accepted the grounding theory. With a properly grounded system, the first fault to ground causes sufficient fault-current flow to operate protective devices and disconnect faulted part of the system. But, if the system doesn't function properly, there's possibility that a larger area than necessary will be shut down. In an ungrounded system, the first accidental connection to ground doesn't cause protectors to operate and there's possibility of spotting the fault and correcting it before the second fault to ground occurs. This is the argument of those favoring ungrounded systems.

Grounding of system neutral has many advantages. Ground-to-conductor voltage is constant, lower than line-to-line voltage and likely to cause smaller fault currents than would occur with second accidental ground on ungrounded system. When ungrounded system is connected to ground accidentally, insulation to ground of other ungrounded conductors is subjected to full line-to-line voltage. What's more, if first accidental ground has high resistance and intermittent arcing occurs (repetitive restrike), very high transient voltages can develop. These voltage conditions are likely to cause failures in other parts of the system. Grounded systems take faults off the line immediately, reducing hazard to personnel and possibility of ignition of combustibles. Ground faults are easy to locate.

Neutrals should be grounded at the source, not at the load; that is, at generators and at the secondaries of transformers. Each voltage level is grounded independently, sketch, right. Where transformer secondary winding is wye connected, ground at the neutral. A neutral can be obtained from a delta-connected secondary by a grounding transformer, as at *B* in sketch.

Grounding may be either *solid*, in which case there's no intentional impedance; *resistance*, where resistance is intentionally introduced to reduce ground-fault current; or *reactance*, where reactive impedance is intentionally introduced between neutral and ground. More complicated methods of controlling ground-fault current make use of resonance.

Method of grounding depends on conditions in particular voltage area of the system and involves calculation of possible fault currents in the area and their effects on protective devices. Common practice is indicated in sketch. In 2.4- to 13.8-kv range, resistance grounding is favored for large systems; solid grounding may be used on small layouts. Transformer *A* and generator *B* are delta connected and grounded through zigzag transformer. In a new installation, of course, you would specify wye connections for generators and transformer secondaries. In voltage range of 600 volts and below, systems generally are grounded solidly at neutrals *D* and *F*. Generators are reactance grounded, *E*, if wye connected, and through grounding transformer if delta connected. A grounding transformer reactance limits current and proper value must be selected.



SYSTEM GROUNDS are made at neutral of generators and transformer secondaries in each voltage level of distribution system

Ground-fault current can be limited substantially by resistance with little compromise of advantages of grounded system. Transitory overvoltages can be anticipated to be held within 2.5 times normal voltage, only slightly greater than the 1.8 value expected of solid grounding. Reactance grounding generally is limited to generators. Reduction of ground-fault current by reactors is kept to about 25% of 3-phase short-circuit current. Otherwise, there's risk of transitory overvoltage troubles due to repeti-

tive restrike in an arc in the ground-fault system. Resistance-grounded system stays free of this trouble.

When only one or two power sources are involved, individual ground connections are favored. If more power sources are to be grounded, a grounding bus may be used to better limit size of ground current. Sources are connected solidly to the bus, and the bus is connected to ground through a single resistance. Breakers are recommended to disconnect inoperative generators or transformers from the bus.

Equipment grounding must be adequate if system grounding is to function properly. All parts of equipment capable of conducting should be connected to ground by bonds that can carry ground-fault current. Fault currents tend to follow a path close to conductor, such as through conduit, rather than through remote path, even if latter has a larger cross section. Reason: higher reactance of the remote-current return path.

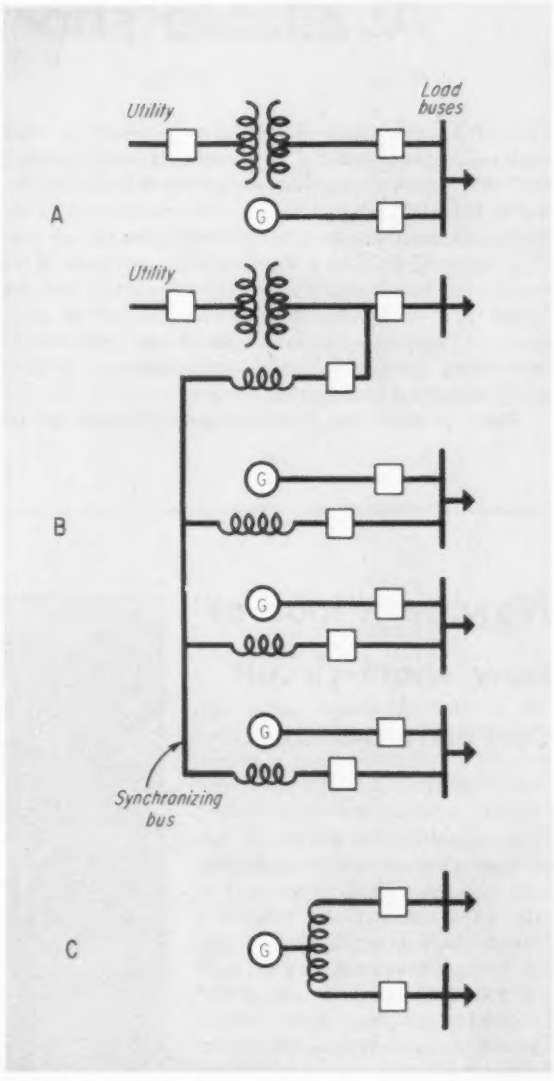
Additional benefits are reaped from grounded system in minimizing lightning and static-electricity hazards.

If you generate power, plan system ties carefully

Where power is both purchased and generated, simplest tie is as shown in sketch *A*, right. This will do the job for many plants, although available switchgear will limit plant's expansion capability. New generator can be purchased with desired reactance, but a series reactor can be used to limit existing generator's contribution to short-circuit current. Since it's in series, reactor also produces some continuous voltage drop and losses.

Synchronizing bus is best solution where there are many power sources or where sources are very large. Sketch *B* shows utility supplying a load bus of its own and also tied to the synchronizing bus through a current-limiting reactor. Load supplied by generators is split up so each generator supplies individual load bus, and is tied to synchronizing bus through a reactor. In this manner interrupting demands on the breakers are much less than if a common load bus was used. New loads and additional incoming capacity may be added to the system. With synchronizing bus, power is transferred automatically to any one bus section from other bus sections if that section's normal power source is lost. Reactors are not normally in series with generators and consequently voltage drop is avoided.

Duplex reactor is a center-tapped reactor used effectively for dividing load on a large generator and reducing magnitude of fault currents, sketch *C*. Direction of winding turns, in the two halves of reactor, is such that with normal current flowing in about equal amounts, the magnetic fluxes are in opposition. This reduces effective reactance between generator and each bus. Fault current, on the other hand, flows through only that half of the winding connected to the faulted circuit. Since there is no canceling flux from the other half of the duplex reactor, the fault current encounters a relatively high reactance. This arrangement results in a lower voltage drop under normal conditions of loading than would be obtained by using series reactors.



PLANT GENERATORS are usually connected to system with arrangement of reactors to limit contribution to short-circuit current

Duplex reactors, like series reactors, are to be avoided in the design of a new system if generators with desired reactance characteristics are available. The principle advantage of duplex reactors is in the modernization of existing distribution systems where you already generate all or most of your own power and have a heavy load concentration. Other schemes for limiting contribution of generators to short-circuit current are available. Investigate them if a survey of your distribution system indicates a serious problem exists in this area.

Available short-circuit current tells

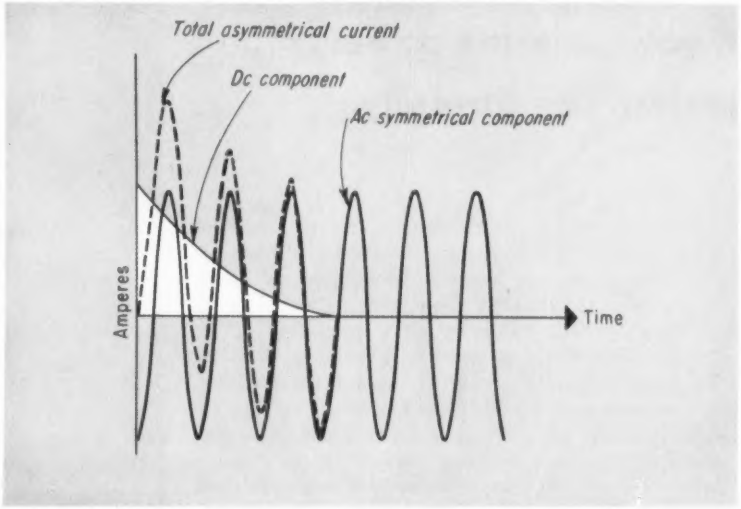
Calculating magnitude of current that will flow under fault conditions is essential for planning circuit protection. Sufficiently accurate calculations are not difficult to make, but in large and complex systems they can become so numerous as to be impractical by longhand methods. Calculating-board facilities are available in many parts of the country, and their cost may be justified where a complex system is to be studied. Short cuts can be used in many cases, too, especially for preliminary checks. These checks may reveal dangerous conditions, prompting you to a more methodical examination.

Basic source of fault current is synchronous and induction rotating machines—generators, motors, synchronous condensers. Impedance of these machines is an important factor in magnitude of the fault current. Impedance of rotating machines is, effectively, a variable reactance which changes rapidly after the initiation of the fault until a steady-state reactance is reached. In the case of a generator, which continues to be driven by its prime mover, steady-state fault current continues until the fault is removed from the system. Synchronous motors supply current to a fault in much the same way as generators, as long as inertia of the load acts as the prime mover.

Variable reactances of synchronous machines can be

Now, let's look at how short-circuit currents behave

Fault calculation for the proper use of protective devices is concerned with maximum fault currents. For sake of simplicity, we assume a "bolted" fault exists; that is, one having no impedance resulting from fault arc. Calculation is further simplified by assuming a 3-phase short circuit — all three phases shorted together. Line-to-line faults are about 87% of 3-phase faults, while ground faults range from about 60 to 125%. Ground faults greater than 3-phase faults are so rare in industrial systems they aren't ordinarily calculated.



ASYMMETRICAL CURRENT in early cycles of fault can be broken into ac, dc components

Fault-current wave is likely to be nonsymmetrical about the zero current-axis for several cycles after the fault occurs. System voltage and fault current are essentially sine-wave in shape and are related by the impedance angle of the system up to the fault. Since the impedance is mostly reactive, the fault current will usually lag the voltage by nearly 90 degrees. This means that when a fault occurs at or near the peak of the voltage wave, the fault current wave will be symmetrical about the voltage axis. When a fault occurs at or near the zero point on the voltage wave, the fault current wave again starts at zero on the original zero axis. However, at the start of the fault, the current should be at or near its maximum because it's out of phase with the voltage by practically 90 degrees. To meet this requirement, the fault current becomes symmetrical about a new zero axis and is offset, or asymmetrical, to the zero axis of the voltage wave.

For convenience, the asymmetrical fault-current wave is considered to have two components: a symmetrical ac wave and a decaying dc component which is superimposed upon it. Magnitude of ac component is determined by E/Z, while magnitude of dc component depends on point on voltage wave at which fault occurred. Dc magnitude can vary from zero to a value equal to the peak of the symmetrical ac component. The initial value of the dc component is equal to the value of the ac component at the instant that the fault occurs. At any instant after the fault occurs the magnitude of the asymmetrical current is the sum of the ac and dc components. For application of protective devices

size of your protection problems

represented by the following three reactance values:

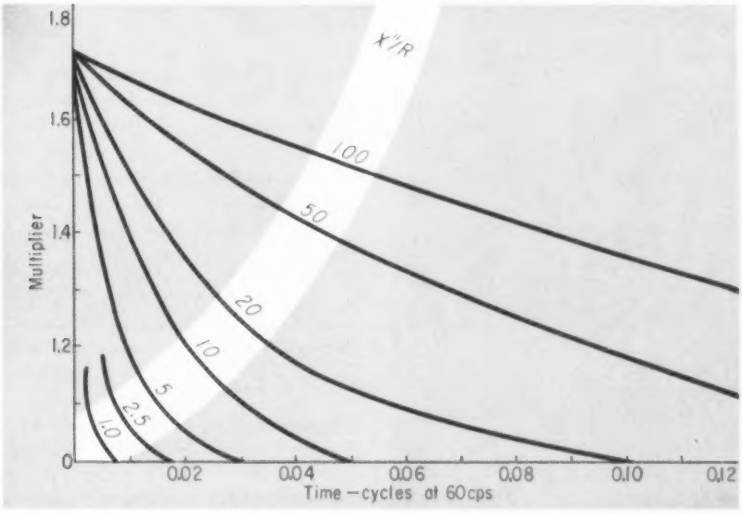
X''_d = Subtransient reactance; determines current during first cycle after fault occurs. In about 0.1 second this reactance increases to:

X'_d = Transient reactance. This value increases in about 0.5 to 2 seconds to:

X_d = Synchronous reactance; determines current after a steady-state condition is reached.

Actual numerical values often will be different for generators and motors. Importance of these reactances depends on what percentage they represent of short circuit's impedance. If fault occurs at generator leads they are very important; but if fault is remote from the source their significance is smaller.

Induction motors contribute to fault current when load's inertia drives motor after fault occurs. Since induction motors are excited by stator winding, and flux drops off when voltage is disconnected, only a subtransient reactance (X''_d) is considered. This value will be about equal to the locked-rotor reactance, hence fault-current contribution will be about the same as the full-voltage starting current of the machine. Subtransient contribution of large induction motors can be a major item in short-circuit calculations under certain conditions.



MULTIPLIERS at various X/R ratios give you asymmetrical current as dc component decays

we are concerned only with the maximum asymmetrical rms value.

Because there's always some resistance in the circuit, the dc component decays to zero as the stored energy which it represents is used up in the form of I^2R losses. Decay rate of the dc component is proportional to X/R ratio of reactance to resistance, considering circuit from source to fault.

Calculation of the precise values of asymmetrical current is very involved. For practical purposes factors based on experience are used to multiply the symmetrical component to obtain the asymmetrical current under particular conditions. Chart, above, gives multipliers to account for decay of the dc component for various values of the reactance-to-resistance ratio, X/R. These multipliers are further combined with factors to account for location of the fault in the system with respect to sources of short-circuit current (rotating machines). Generally accepted multipliers are given in table, page 83.

Circuit breakers, fuses and other protective devices are usually rated in rms values rather than peak values. The multipliers are therefore applied to the rms symmetrical ac component determined in the short-circuit calculations. Total ac symmetrical current at the fault is the sum of the currents contributed by the various sources (rotating machines), which may have different decrement rates depending on their variable reactances. The utility source can be considered a steady-state value in most cases.

Circuit protectors (except current-limiting fuses) must be capable of withstanding maximum short-circuit current. This current occurs during the first loop of the asymmetrical wave and produces mechanical stresses proportional to the square of the current. The protector must be strong enough to withstand these forces. The corresponding current is known as its *momentary* or *withstand rating*. Interruption of the current occurs after the current has dropped off, generally one to eight cycles later. After eight cycles the dc component usually has been reduced considerably. Rating schedules of power circuit breakers are so proportioned that their momentary rating is about 1.6 times the maximum interrupting rating. In circuits where motors contribute to short-circuit current, take care that the momentary rating isn't exceeded even though the interrupting rating is adequate. The *four-second rating* is the current which a protector will carry for four seconds without damage, principally of thermal origin.

You must know circuit impedances

Fault current is found by applying Ohm's law, $I = E/Z$, where I is the current, E is normal system voltage at point of fault, and Z is impedance of circuit between fault and source, including the impedance of the source. The voltage which serves as a basis for current calculations is the line-to-neutral voltage, which is the rated line-to-line voltage of the generator or transformer supplying the faulted area divided by $\sqrt{3}$.

In ac circuits, impedance is the vector sum of reactance and resistance:

$$Z = \sqrt{X^2 + R^2}$$

In major elements, such as generators and transformers, reactance is usually at least five times the resistance. Neglecting resistance in fault calculations will, in general, introduce an error of only a few percent; this error is on the safe side as far as protective devices are concerned. Because of this, modern practice disregards resistance of generators, transformers, motors, reactors and large bus work, regardless of system voltage.

In systems above 600 volts, resistance of circuit elements, such as cable and bus duct, is generally neglected. Below 600 volts, resistance of feeders should be considered in most cases. A good rule is: If resistance of feeder is one-quarter or more of reactance from source to fault, resistance should be included in the calculations. Resistance should then be total resistance of the circuit to the fault. Also keep in mind that reactances of all circuit elements are important in limiting short-circuit current in low-voltage circuits, so include them all.

Reactances and complete impedances to be considered for various circuit elements are summarized in table, below. Tables giving specific values of impedance and reactance for these types of equipment can be found in handbooks or obtained from makers.

Principal problem of short-circuit current calculation is determining reactance of circuit. To obtain it, reactance of each significant circuit element must be found and the elements combined in series or parallel. Three systems can be used to express system reactance: (1) ohms (2) percent (3) per unit on kva base. Most engineers prefer the latter and we'll stick to it in this report. When reactances are expressed as per-unit quantities on a chosen kva base, they can be combined directly without regard to transformer turns ratio in systems having more than one voltage.

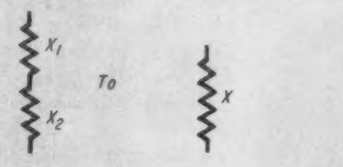
Here are conversion equations for the three systems:

$$\text{Per-unit reactance} = \frac{\text{percent reactance}}{100}$$

$$\text{Per-unit reactance (on chosen kva base)} = \frac{\text{ohms} \times \text{kva base}}{1000 \times \text{kv}^2}$$

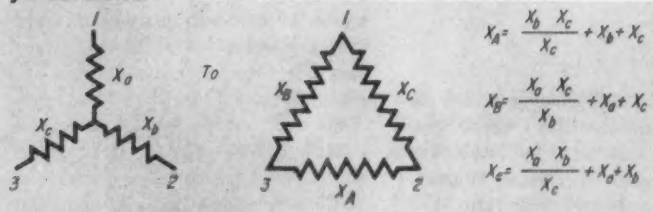
$$\text{Percent reactance (on chosen kva base)} = \frac{\text{ohms} \times \text{kva base}}{10 \times \text{kv}^2}$$

Branches in series

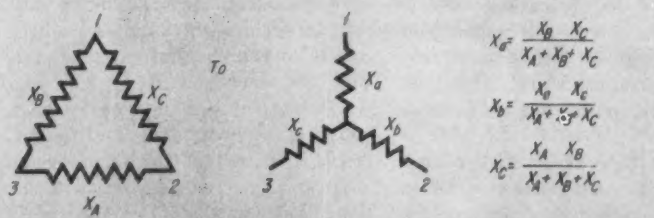


Branches in parallel

Wye to delta



Delta to wye



COMBINATION of impedances follows simple rules to reduce complex circuits to more easily handled values. Diagram is made from these reactances

Reactances or impedances needed for calculations

Equipment	Above 600 v	Below 600 v
Utility supply	X	X
Main plant substation trans.	X	X
Plant generator	X	X
Plant primary feeders	X	X
Plant secondary substations	X	X
Plant distribution circuits	X	X
Branch feeder circuits		Z
Motors	X	X
Low-voltage bus		Z
L-v circuit breakers		X
Current transformers		X
Current-limiting reactors	X	X

Machine reactances and multipliers to get asymmetrical current

Classification	Circuit voltage	Location in system	Multiplying factor	Machine reactances to use: Generators / Synchronous converters / Synchronous condensers / Frequency changers	Synchronous motors	Induction motors
Power circuit breakers				**Interrupting duty**		
Eight cycle or slower (general case)	Above 600 v	Any place where symmetrical short-circuit kva is less than 500 mva	1.0	Subtransient	Transient	Neglect
Five cycle	Above 600 v		1.1	Subtransient	Transient	Neglect
				Momentary duty		
General case	Above 600 v	Near generating station	1.6	Subtransient	Subtransient	Subtransient
Less than 5 kv	601 to 5 kv	Remote from generating station (X/R ratio less than 10)	1.5	Subtransient	Subtransient	Subtransient
High-voltage fuses				**Maximum rms ampere interrupting duty**		
All types, including all current-limiting fuses	Above 600 v	Anywhere in system	1.6	Subtransient	Subtransient	Subtransient
Noncurrent-limiting types only	601 to 15 kv	Remote from generating station (X/R ratio less than 4)	1.2	Subtransient	Subtransient	Subtransient
High-voltage, fused motor starters				**Maximum rms ampere interrupting duty**		
All horsepower ratings	2400 & 4160 v	Anywhere in system	1.6	Subtransient	Subtransient	Subtransient
High-voltage motor starters				**Interrupting duty**		
Circuit breaker or contactor type	601 v to 5 kv	Anywhere in system	1.0	Subtransient	Transient	Neglect
				Momentary duty		
Circuit breaker or contactor type	601 v to 5 kv	Anywhere in system	1.6	Subtransient	Subtransient	Subtransient
Circuit breaker or contactor type	601 v to 5 kv	Remote from generating station (X/R ratio less than 10)	1.5	Subtransient	Subtransient	Subtransient
Apparatus, 600 volts and below				**Interrupting or momentary duty**		
Air circuit breakers or breaker-contactor combination motor starters	600 v or less	Anywhere in system	1.25	Subtransient	Subtransient	Subtransient
Low-voltage fuses or fused combination motor starters	600 v	Anywhere in system	1.25	Subtransient	Subtransient	Subtransient

Ohms are line-to-neutral values, kva base is the 3-phase base kva, and kv is line-to-line voltage.

To apply per-unit calculations, you must choose a base kva. This can be any convenient base, such as the rating of the largest kva unit – motor, generator, transformer – in the system. Reactances for cables, buses, current transformers, air circuit breakers, etc will be given in ohms. These values can be converted to per-unit reactance by the above formulas. Transformers, generators, motors, etc will normally have their reactance expressed in percent reactance based on their own kva rating. Equipment reactances must be converted to the *chosen base kva* using these formulas:

$$\text{Per-unit reactance (on chosen kva base)} = \text{per-unit reactance on kva rating} \times \frac{\text{base kva}}{\text{kva rating}}$$

The utility system considered as source has a reactance which must be included in the impedance diagram of the plant system. Sometimes the utility will supply you with a percent reactance on a certain base, in which case you merely convert this value to the common base used for equipment in the reactance diagram. Often the utility's engineers will supply the available short-circuit current or kva value. In cases where the utility provides the protector on the incoming line, only the protector's interrupting capacity may be known.

To convert short-circuit kva:

$$\text{Per-unit reactance (on chosen kva base)} = \frac{\text{chosen kva base}}{\text{short-circuit kva of utility}}$$

If only protector's interrupting capacity is known, use it as utility's short-circuit kva in the formula.

One-line diagram of the plant's distribution system must include all equipment with significant impedance – generators, transformers, buses, cables, motors, etc. One-line diagram serves as guide for collecting impedance data, and as data is added it becomes an impedance diagram. After converting all impedances to per-unit values, impedance diagram takes the form shown in example on the following page.

Per-unit reactances are combined in the same manner as though they were expressed in ohms. Resultant of successive combinations is a single per-unit reactance representing the reactance of the faulted circuit. We refer to diagram as *reactance diagram* because we are concerned chiefly with reactance; actually it is an impedance diagram because resistance values have been included where they play a significant part in total impedance.

Your 4-step guide to figuring fault current

1 Get reactance ratings

Starting with the one-line diagram, get reactance ratings for all equipment. Enter on diagram.

2 Convert to per unit on base kva

For one-line diagram below, choose 10,000 kva as a base, since this value is easy to work with, being neither too large or too small. Proceed as follows:

Utility supply equivalent reactance

$$\text{Per-unit reactance} = \frac{10{,}000 \text{ kva base}}{1{,}000{,}000 \text{ kva}} = 0.01$$

3000-kva transformer, 7% reactance on rated kva base

$$\text{Per-unit reactance on kva base} = \frac{7 \times 10{,}000}{100 \times 3000} = 0.233$$

625-kva generator, $X''_d = 9\%$ reactance

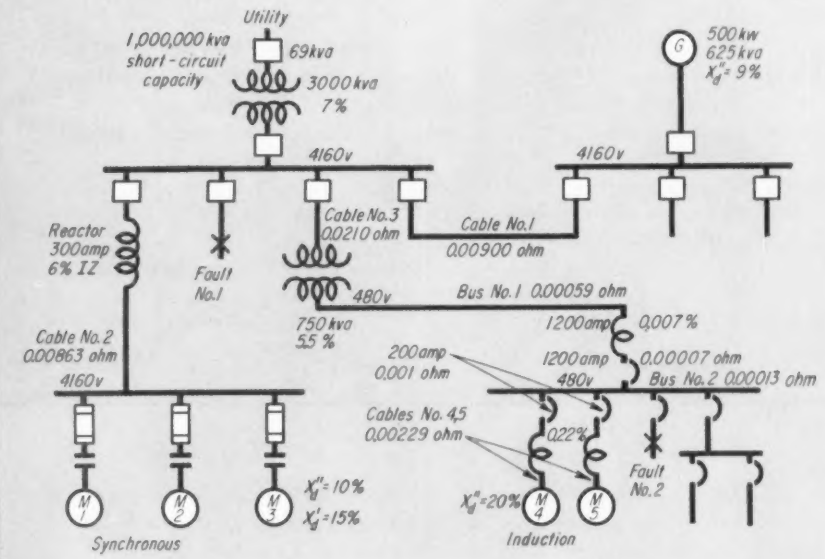
$$\text{Per-unit reactance (base)} = \frac{9 \times 10{,}000}{100 \times 625} = 1.44$$

Cable No. 1, 300 ft, 0.030 ohm per 1000 ft at ½-in. spacing = 0.0090 ohm

Per-unit reactance (base) = 0.0090 × 0.576 = 0.00518

Cable No. 2, 500 ft, 0.0636 ohm per 1000 ft at ¾-in. spacing = 0.01725 ohm. Two parallel cables = ½ × 0.01725 = 0.00863 ohm

Per-unit reactance (base) = 0.00863 × 0.576 = 0.00496

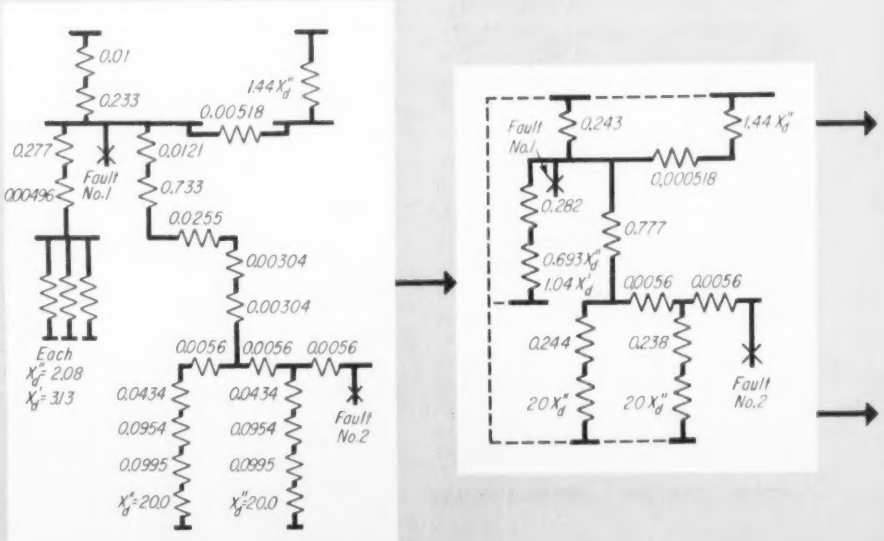


One-line diagram

One-line diagram of hypothetical system shows all equipment having reactance significant for short-circuit current calculations. Reactance of different types of equipment will be expressed in different ways. Transformers in the one-line diagram are rated in percent reactance on their own kva base, while air circuit breakers are rated directly in ohms. Cables and bus reactance must be figured from charts and tables as so many ohms per 1000 feet, depending on the size of the conductor and the space configuration. Reactances of the rotating machinery are expressed in per unit on the machine's own base.

Reactance diagram

Reactance diagram replaces the one-line diagram after variously expressed reactances have been converted to per unit on the chosen kva base. To simplify the diagram, you can combine the reactances. After the second stage in our example, each fault must be treated separately. Because of the location and type of the protectors, both momentary (½ to 1 cycle) and interrupting (8 cycles) values must be found for Fault No. 1. That is, calculations must be made using X''_d and also X'_d. For Fault No. 2 only X''_d need be used.



Cable No. 3, 700 ft, 0.030 ohm per 1000 ft
at ½-in. spacing = 0.021 ohm
Per-unit reactance (base) = 0.021 × 0.576 = 0.0121

Current-limiting reactor
Per-unit reactance on reactor's base = 0.06

$$\text{Per-unit reactance (base)} = \frac{0.06 \times 10{,}000}{2{,}160} = 0.277$$

750-kva transformer, 5.5% reactance

$$\text{Per-unit reactance (base)} = \frac{5.5 \times 10{,}000}{100 \times 750} = 0.733$$

600-hp synchronous motors
Per-unit reactance on motor base of 480 kva:
$X''_d = 0.10$; $X'_d = 0.15$
Per-unit reactance (base):

$$X''_d = \frac{0.10 \times 10{,}000}{480} = 2.08$$

$$X'_d = \frac{1.15 \times 10{,}000}{480} = 3.13$$

Bus No. 1, 12 ft, 0.000049 ohm per ft
at specified spacing = 0.000588 ohm
Per-unit reactance (base) = 0.00058 × 43.4 = 0.0255

Bus No. 2, 2-ft section, 0.000645 ohm per ft
at specified spacing = 0.000129 ohm
Per-unit reactance (base) = 0.000129 × 43.4 = 0.0056

Cables No. 4 and 5, 60 ft, 0.0381 ohm per 1000 ft
at 1-in. spacing = 0.00229 ohm
Per-unit reactance (base) = 0.00229 × 43.4 = 0.0995

100-hp induction motors
Per-unit reactance on motor base of 100 kva: $X''_d = 20$
Per-unit reactance (base):

$$X''_d = \frac{0.20 \times 10{,}000}{100} = 20$$

Air circuit breakers
Reactance of 1200-amp breaker =
0.00007 ohm; 200 amp breaker = 0.001 ohm
Per-unit reactance (base):
of 1200-amp breaker = 0.00007 × 43.4 = 0.00304
of 200-amp breaker = 0.001 × 43.4 = 0.0434

Current transformers
Reactance of 1200-amp ct =
0.00007 ohm; 200-amp ct = 0.0022 ohm
Per-unit reactance (base):
of 1200-amp ct = 0.00007 × 43.4 = 0.00304
of 200-amp ct = 0.0022 × 43.4 = 0.0954

With all reactances expressed on a common 10,000-kva base, construct the reactance diagram following the pattern of the one-line diagram.

3 Combine reactances

Combine reactances to get reactance diagram without series reactances. Motors and generators are considered to be connected by their "neutral" or "center" points to the same bus as is the utility supply equivalent reactance. Therefore, the latter is considered to be in parallel with the motor and generator reactances.

4 Find fault current or kva

$$\text{Symmetrical kva} = \frac{\text{base kva}}{\text{per-unit reactance of fault}}$$

$$\text{Symmetrical amp} = \frac{\text{base kva}}{\text{per-unit reactance of fault} \times \sqrt{3} \times \text{kv}}$$

The asymmetrical current then is found by using the appropriate multiplier from table on p 83.

To conclude the example, apply the three equivalent reactances found to the formulas above:

Fault No. 1 — momentary

$$\text{Symmetrical rms amp} = \frac{10{,}000}{0.169 \times \sqrt{3} \times 4.16} = 8{,}220$$

Asymmetrical rms amp = 1.6 × 8,220 = 13,140

Fault No. 1 — interrupting

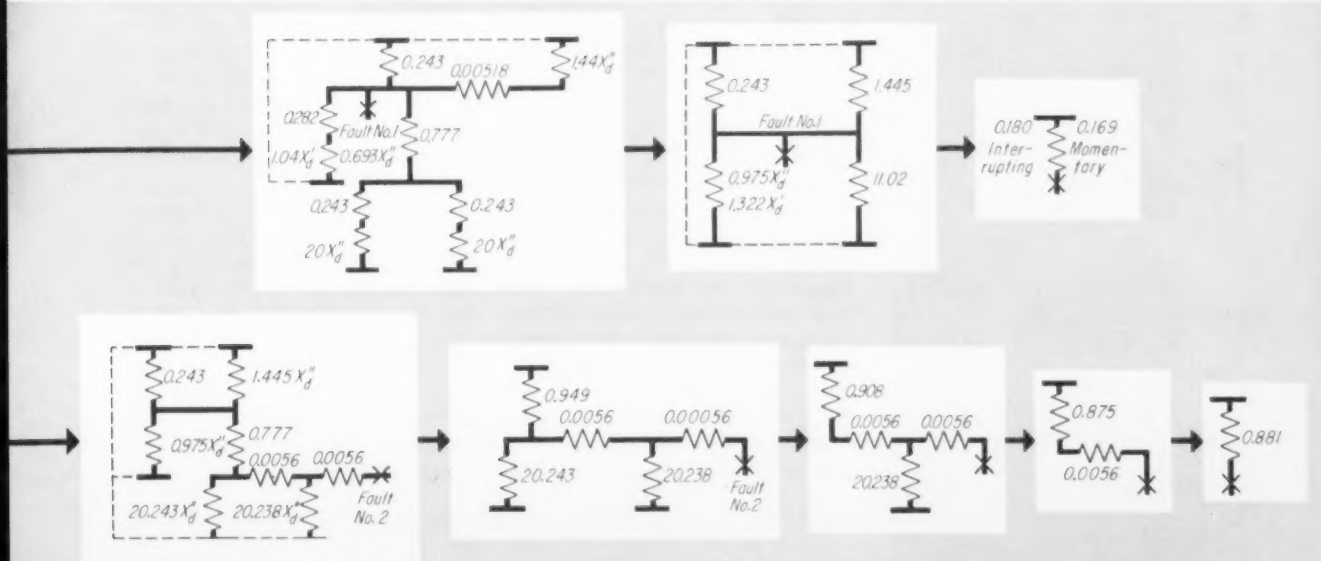
$$\text{Symmetrical rms kva} = \frac{10{,}000}{0.180} = 55{,}600$$

Asymmetrical value is the same since dc component has disappeared by time of interruption (8 cycles).

Fault No. 2

$$\text{Symmetrical rms amp} = \frac{10{,}000}{0.881 \times \sqrt{3} \times 0.48} = 13{,}620$$

Asymmetrical rms amp = 1.25 × 13,620 = 17,020



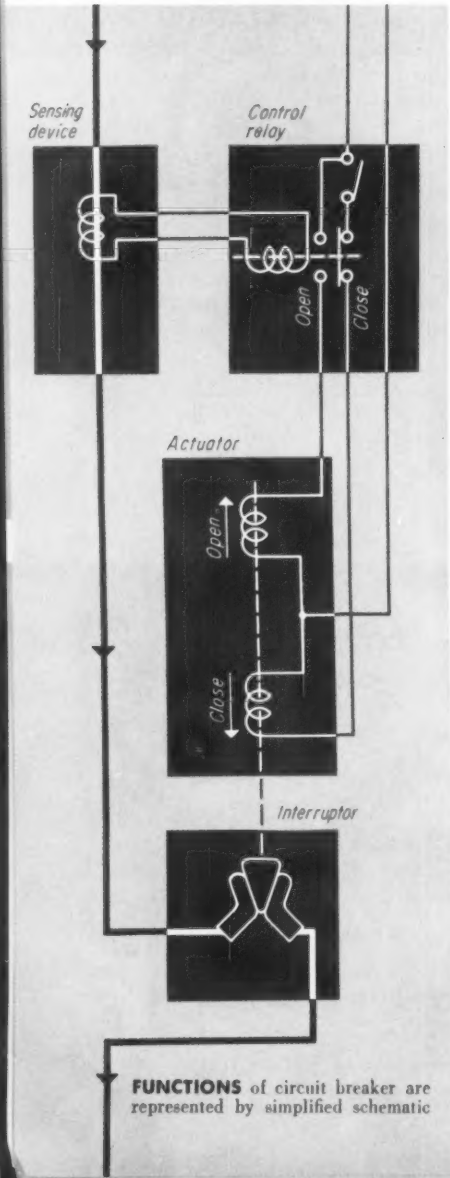
Today's versatile, rugged protective

Main purpose of protective devices, as we have seen, is to interrupt fault current in order to remove the fault from the system. Circuit breakers and fuses come into play for this purpose. Circuit breakers are essentially switches with special characteristics. Fuses usually are used in combination with switches or circuit breakers.

Circuit breakers and fused switches are intended to open and close circuits in normal operation. This means that they should be capable of being opened safely at any current up their interrupting rating, and closed safely on any fault that produces current up to their interrupting rating. Never apply an interrupting device beyond its capacity to handle available short-circuit current. Where it is economically feasible, it is a good idea to provide capacity for growth of load and available fault current.

Circuit breakers and fuses are made in a wide variety to meet requirements of particular applications. The next few pages describe how general types of protective devices work and what can be expected of them. Suggestions for selecting protectors to meet your individual needs will be found on pp 101-103.

General classifications of circuit breakers in common use today are (1) oil (2) air blast (3) air-magnetic and (4) molded-case types. Fuses are (1) one-time (2) lag (3)



FUNCTIONS of circuit breaker are represented by simplified schematic

Circuit breakers offer varied protection

Circuit-breaker protection involves four basic components: (1) A sensing device which measures the quantity to be controlled, such as a current transformer. (2) A relay which interprets the signal from the sensing device and initiates the proper circuit-breaker response. (3) An actuating mechanism (frequently called an operator) which opens and closes the contacts, such as a solenoid and linkages. (4) An interruptor consisting of the contacts and arc-controlling parts.

In small circuit breakers all these components may be included in one unit. Larger circuit breakers are likely to have separate relays and sensing devices, which adds greatly to their flexibility.

Protective applications of relays are numerous and can be called on to obtain a high degree of system reliability. Most commonly, we deal with overcurrent relays which respond to fault current. Differential relays are used to protect large motors, generators and transformers; winding temperature relays are applied similarly. Transformers with conservators have sudden-pressure relays. Reverse power relays are used with network protectors. Undervoltage and overvoltage relays, reversed phase relays, and ground-fault relays often work their way into the picture.

In this report we can't go into relaying problems. Simple hookups are readily available from circuit-breaker manufacturers; maximum-reliability systems require special techniques.

Most large circuit breakers use induction type relays for fault-current protection. Relay is similar to a single-phase motor producing torque proportional to measured current. Counter-torque is supplied by a spring. Sufficient rotation closes control circuit contacts. Induction relays are accurate and easily adjustable. Thermal and electromagnetic-attraction relays find use in smaller circuit breakers.

Overcurrent relays may be instantaneous, but in general it's desirable to have time delay in order to get co-ordination. Inverse-time relays function faster when the current is large. Overcurrent relays are available with *inverse*, *very inverse* and *extremely inverse* time characteristics to fit particular needs.

Actuating mechanism (or operator) for large circuit breakers is frequently a solenoid with mechanical linkages. This solenoid is usually dc and may be operated from a battery or through a rectifier. One coil opens the contacts (trip coil), another closes them (the closing coil), although reclosing may be manual in some cases. Another actuating mechanism uses the stored energy principle; a spring

equipment handles tough assignments

dual-element (4) expulsion and (5) current-limiting types.

In addition to these established circuit interruptors, there are several devices being put through the paces in other fields. Many of these promise to work their way into the distribution areas with which we are concerned.

Oil cutouts, with a long history in utility transmission, are finding application in industrial systems as primary substation protectors.

Vacuum switches are in use by utilities at high transmission voltages, mainly for capacitor switching. Principle of these switches is attractive: current is broken in vacuum and there is no gas to ionize. However, problems have shown up in practice. Two kinks that must be worked out are restriking and deterioration of vacuum. It's still too early to predict the future of this type of device.

Gas switches using sulfur hexafluoride also are being used by the utilities. Results are promising, and this switch may come indoors one of these days. Sulfur hexafluoride has excellent arc-quenching properties, is not toxic or flammable. Gas switches may replace oil in the not-too-distant future if improvements keep up their current pace. Gas has long life; experience indicates frequent recharging with gas isn't necessary. Decomposition products caused by the arc are small in quantity and are kept harmless.

through relaying

is wound manually or by a small motor and released when needed to operate the breaker, p 93. Pneumatic and hydraulic mechanisms employ a small electric valve or valves to initiate action — fluid pressure providing the actual force. Remote manual reclosers work similarly.

Operation is either manual or automatic. Most smaller breakers are closed manually and closing action stores energy for tripping the breaker. The built-in relay trips a latch. During switching operation, these smaller breakers are opened and closed manually; tripping is automatic on fault interruption, but reclosing is manual.

It is always possible to reclose on a fault. But great care must be taken for if breaker interrupting capacity is inadequate, the person closing the breaker can be injured or killed. Quick forceful closing action is desirable in such cases in addition to adequate capacity. Some designs of circuit breakers supply this by the mechanism, not making it dependent on how your man operates the handle of the breaker. Automatic operation opens and closes the breaker in response to remote relays. Remote manual operation can be had with electrical pushbutton stations. Sometimes it is desirable to have the breaker reclose automatically a few times before remaining open. This gives minimum interruption of service when fault is transient or is cleared by a protector farther out on the system. Timing is such that reclosing on fault does not damage the equipment.

Ratings of circuit breakers are specified according to standards of NEMA and ASA and recommendations of AIEE. Breakers are classified according to voltage and interrupting capacity. Interrupting capacity of circuit breakers has gone up steadily along with growth of power demands.

Voltage. First, there's the nominal voltage class which helps to identify the breaker; for example, a "4.16-kv class breaker." The maximum design voltage is actual limit to operation. It allows some leeway in system voltage, plus 10% for voltage regulation. Thus, a 4.16-kv class breaker has a maximum design kv of 4.76. This permits its use on 4330-volt systems, but not on 4600- or 4800-volt systems. Minimum operating voltage is lowest voltage at which breaker will interrupt rated mva. It will interrupt at lower voltages, but mva interrupted must be reduced accordingly. This rating reflects the maximum current that the breaker can handle.

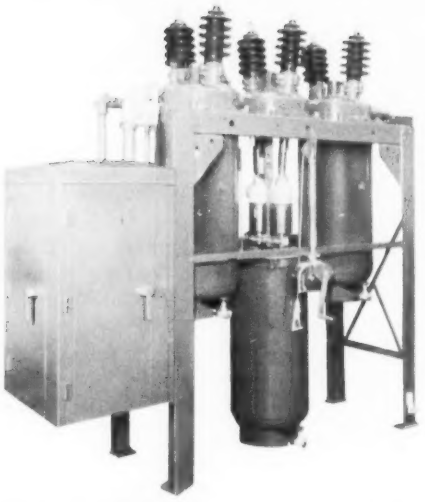
Continuous rating is current breaker will carry continuously; it's maximum load current of the circuit.

Momentary and *4-second ratings* are maximum currents breaker will stand for ½ to 1 cycle and for four seconds respectively, p 81. Latter allows for necessary time delay in coordinating breakers.

Interrupting ratings for circuit breakers above 600 volts are the 3-phase mva values which the breakers will interrupt from the maximum design voltage down to the minimum operating voltage. A maximum current rating is applied: this is maximum amperes breaker interrupts no matter how low the voltage drops. In range below 600 volts, interrupting ratings are in amperes.

Time ratings are interrupting time and reclosing time. Former is maximum time required to interrupt current after trip coil is energized, usually a matter of eight cycles or less. Reclosing time is another matter; it refers to automatic reclosing at specified intervals after fault. This may be 20 or 30 cycles after first opening. How soon breaker closes after second, third, etc opening on the same fault depends on breaker's ability to absorb heat and stresses of fault current. Usually 15 seconds elapses between close-open actions after first or second try. Program of close-open actions and intervening delays is reclosing duty cycle of breaker. Automatic reclosing of this type is of interest only with large power circuit breakers.

Oil circuit breakers are high-voltage work horses



TANK-TYPE OIL BREAKERS have separate tanks for each pole in ratings 15-kv and above; may have single tank in lower ranges

Oil circuit breakers interrupt the current under oil, utilizing the gas formed by the decomposition of the oil to extinguish the arc. There are two general types: the full-oil or dead-tank, and the low-oil-content.

Construction of a typical dead-tank breaker is shown on facing page. This is the oldest type of circuit breaker, and today is still the leading type by a wide margin in the United States for voltages above 13.8 kv.

The name *dead-tank* comes from the fact that the tank is at ground potential and is insulated from the live parts by the oil. Breaker is double-break type, as shown in sketch. Actuating mechanism (operator) is outside the tank and moves the vertical actuator rod through linkages. Make-and-break contacts are bayonet type, fitting into tulip-type stationary contacts.

Arcing takes place between tip of bayonet and beveled flange on the tulip contact. Once the bayonet has completed its upward travel, low-resistance contact is obtained between sides of bayonet and inner surface of tulip. In larger breakers it's customary to have additional metal-leaf contacts which close after the bayonet contacts and open before them, thus carrying most of the continuous current, but not interrupting arc current.

High-speed operation is important incentive to breaker designers. Problem is interrupting arc. Most engineering effort is pointed toward improving arc-interrupting chamber. How typical interruptor works is shown, sketch, facing page. These are forms of "suicide" interruptors; in these the greater the arc the more it accelerates the formation of gas pressure and oil movement, and the faster the arc is extinguished. Breaker interrupting time ratings are based on at least 25% of maximum interrupting current. Small currents, especially at low power factors, are slower to be extinguished.

Oil-impulse breakers were designed to overcome the low-current limitations of suicide interruptors. In impulse breakers a jet of oil is forcibly inserted into the arc and extinguishes it. This oil is supplied by a piston operated by stored energy. Some advantage in speed is gained by impulse breakers at expense of greater cost and more complicated maintenance.

Low-oil-content breakers (also called oil-poor and live-tank circuit breakers) have small oil tanks which contain enough oil for arc-extinguishing action, but don't use the oil for insulation to ground. Low-oil-content breakers are generally of the impulse type. Chief advantage is lower quantity of oil required. This has led to their adoption in Europe, but hasn't been incentive to their increased use in United States. Oil needs more attention, breaker is somewhat more complex.

High-power applications often call for use of oil circuit breakers. They're simple compared with other types. The process of oil disintegration is a very effective way to absorb energy, and oil is an excellent dielectric. Chief disadvantages of oil breakers derive from secondary considerations about oil. Oil has to be maintained — filtered and tested. It's messy to handle and in tank type breakers can be very heavy. While some engineers point out that modern oil breakers are practically explosionproof, a fire hazard, however remote, is involved. This causes some people to hesitate to use oil breakers where an oil fire might spread. Cost of oil is rarely, if ever, a consideration in U.S.

Voltage ratings for oil circuit breakers range from 2.3 kv (nominal 2.5 kv) upwards in nominal steps of 4.16, 7.2, 13.8, 14.4, 24.5, 46 and 69 kv. Oil breakers are also classified as *indoor* and *outdoor*. Panel-mounted indoor breakers at 2.5 kv are rated as high as 400 amp continuous and 6500 amp momentary, with interrupting ratings of 15 mva. Rated interrupting time is eight cycles, actual time may be as fast as 3, 4 or 5 cycles. At 69 kv, ratings can go as high as 2000 amp continuous, 49,000 amp momentary and 3500 mva interrupting.

Bushing standards have been established by ASA. Two sets of dimensions for voltage range up through 69 kv, makes bushings readily interchangeable on all new oil circuit breakers and many older models.

Actuating mechanisms (operators) have stirred up much interest in recent years, especially pneumatic devices.

Object is to make operation as foolproof as possible and avoid accidents by improper sequence of operation.

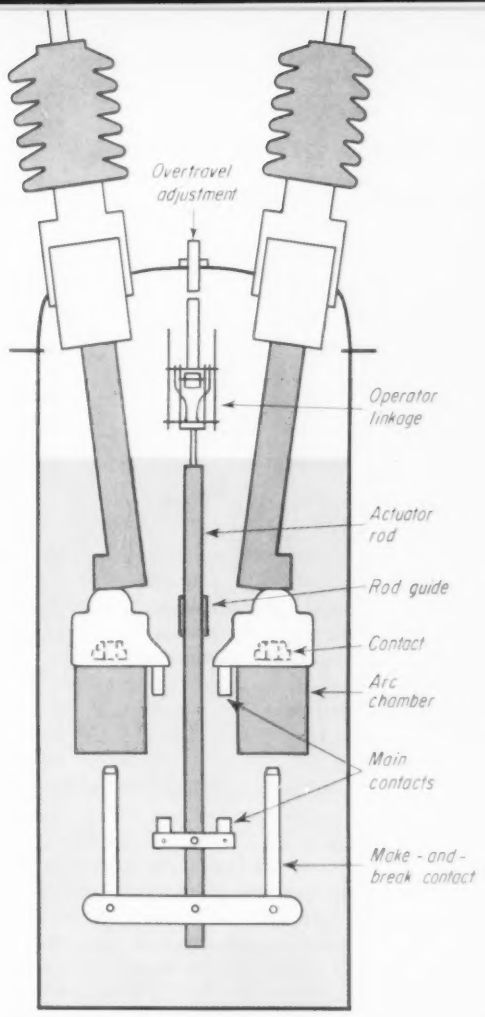
A breaker is *mechanically trip free* when the tripping mechanism can trip it even though in a manually operated breaker the operating lever is held in the closed position. In an electrically operated circuit breaker, the definition of mechanically trip free holds when the circuit breaker can trip even though the actuating mechanism is held in the closed position, either electrically or by means of a maintenance holding device. The trip-free principle is further extended.

A breaker is *pneumatically trip free* if the tripping mechanism can trip it by releasing the closing air pressure even though the closing mechanism is energized. It will not reclose after tripping until the breaker's closing circuit is opened and closed again.

A breaker is *electrically trip free* when the tripping mechanism can trip it even though the closing control circuit is energized. The closing mechanism will not reclose after tripping until the closing circuit is opened and closed again. (Trip-free operation is more precisely defined in NEMA standards.)

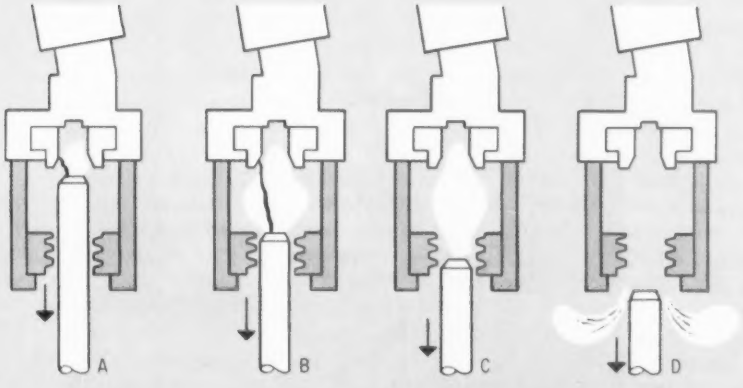
Auxiliary equipment for oil circuit breakers consists mainly of the power supply for the operating circuit. Batteries have been favored for solenoid operation and have a high degree of reliability since they constitute a separate source of power independent of ac supply. There is a maintenance consideration, however, particularly in industrial plants unaccustomed to battery care.

Dc control using rectifiers and transformers gives excellent operating results, but reliability depends on source of ac. Pneumatic operators require a source of air, usually provided as part of the circuit breaker unit. Air reservoir is sufficient for numerous operations, and is replenished by compressor driven by ac motor. Control valves may be ac or dc, with direct current supplied by a rectifier. Hydraulic actuators can also be controlled electrically.



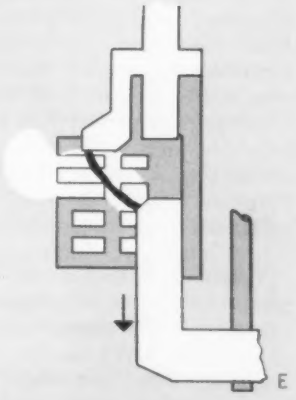
TYPICAL OIL BREAKER has contacts submerged in tank of oil. Smaller sizes sometimes let make-and-break contacts carry load

Here's how oil breakers extinguish the arc



As the bayonet contact moves downward an arc *A* is drawn. The arc produces a high-pressure gas bubble, which in turn keeps down arc energy. Pressure increases rapidly, intensifying natural deionization. As bayonet enters helical throat passage, turbulent oil surges against arc *B*. At next current zero, arc is extinguished, *C*. High gas pressure causes quick dielectric recovery, forces unimpaired oil through arc path. Complete withdrawal of bayonet lets gas bubble escape, *D*. Oil enters to refill the arc chamber

Another type arc chamber



U-shaped iron plates embedded in fiber grid structure are magnetized by arc current. Flux forces arc out into fresh oil in the vented grid pockets. Here, cooler un-ionized gas mixes with ionized arc gas causing rapid dielectric recovery

Air-blast breakers take over h-v jobs when oil is ruled out

For indoor service at voltages above 15 kv air-blast breakers have gained many supporters in recent years

Air-blast breakers in distribution area are commonly called "station-type" breakers and are metal-enclosed or "cubicle" switchgear. In typical operation, sketch below, magnetic valve responds to control circuit signal and an instant later opens to admit compressed air to top of piston in pneumatic mechanism. As the piston moves downward, the mechanical linkages pull back the contact arm, opening the contacts and drawing an arc. Simultaneously, the linkages open the blast valve and compressed air is released through the blast tube directly into the arc path. As the contacts part, this blast of air carries the arc up into the arc chute where the arc is extinguished quickly. The arc gases are cooled before they pass out into the atmosphere.

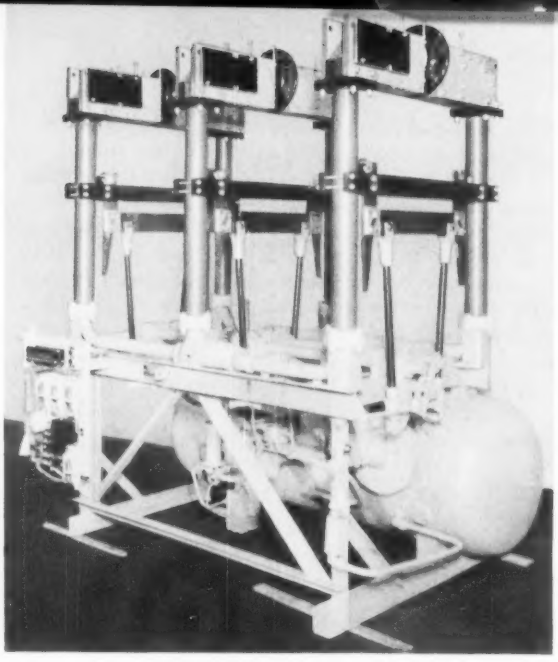
When the contacts have opened sufficiently to insure complete interruption, the blast valve closes. To close the breaker, the lower magnetic valve admits compressed air to the bottom of the piston which closes the contacts forcefully at high speed. Air storage capacity provides two (or more, depending on design) close-and-open operations before more air is needed. Pressure switches prevent operation of the breaker if air pressure falls below set values for opening and closing. In addition to parts shown in sketch, a combination cooler-muffler often is provided to further cool exhaust gases and reduce noise.

Voltage ratings for station type air-blast breakers are either 14.4 or 34.5 kv; others are built for 69 kv. Continuous current ratings range from 1200 to 5000 amp, momentary 61,000 to 190,000 amp. Interrupting ratings go from 500 to 3500 mva. Standard interrupting time rating is eight cycles, but some are capable of 3-cycle interruption. High-speed operation is, in fact, one of the features recommending air-blast breakers. Unlike oil breakers, they interrupt small currents faster than large ones, and have found favor for capacitor switching.

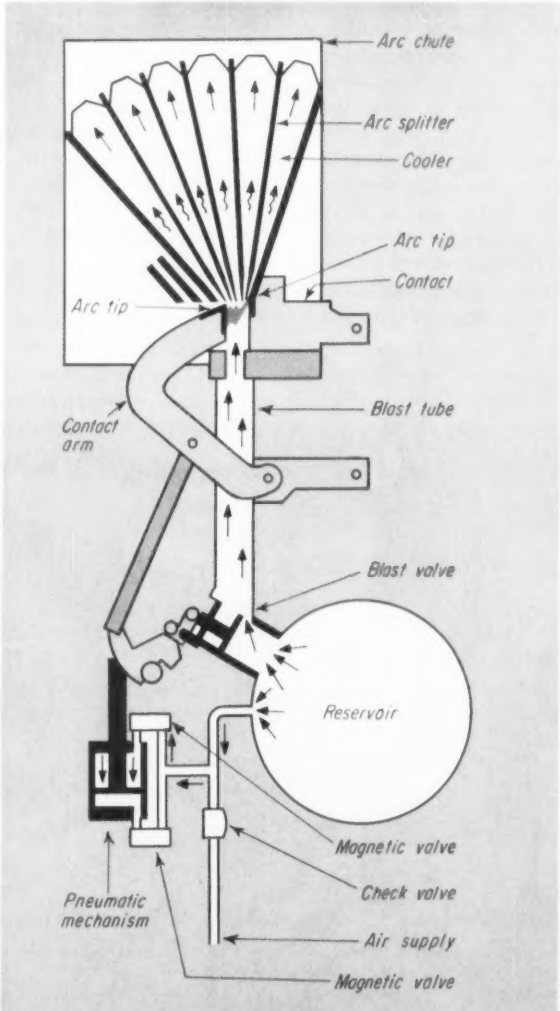
Compressors are supplied with the breaker, either as individual units, or as a central compressed air supply. Air for breakers must be thoroughly dry, and dehydrating equipment is part of the installation. While the interruptor itself is fairly simple, precision air controls require skilled, though infrequent, maintenance.

Trip-free operation is provided with station type breakers. This is accomplished in some designs by an air line between the opening and closing control valves so closing valve won't function when the opening valve is energized. When the breaker is closed on a fault, the opening control valve is energized immediately and the closing valve is closed, emptying the closing cylinder.

Electrical interlocking is easily incorporated since air is controlled through the magnetic valves.



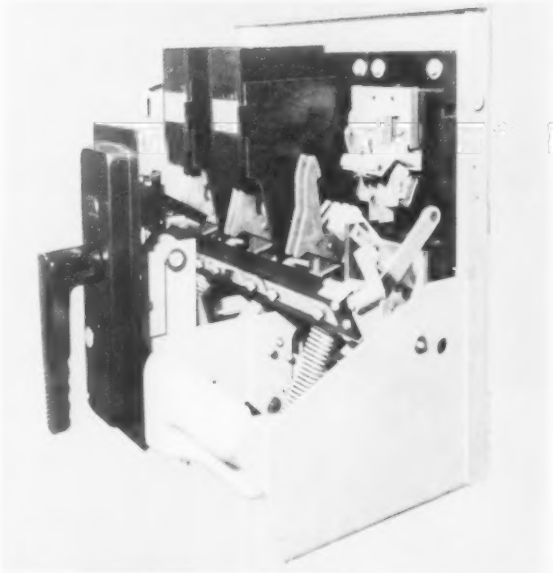
AIR-BLAST CIRCUIT BREAKER with arcing chambers at top. Air is fed through hollow vertical supports from reservoir at bottom



BLAST OF AIR is released simultaneously with opening of contacts and extinguishes the arc rapidly

Air-break circuit breakers fill versatile role today

Spanning entire range from 208 volts through 13.8 kv, popularity of these breakers has spurred increased capacity, reduced physical dimensions



TYPICAL AIR-BREAK circuit breaker with cover and one arc chute removed. Compact construction is suited to metal-enclosed gear

Contacts of air-break circuit breakers open in normal ambient atmosphere. The ambient air is the dielectric which must be inserted into the arc. Fundamental simplicity of this device is its big feature. Principle of operation and typical constructions are described on pp 92-93.

Air-break types are divided into two broad groups: air-magnetic breakers and molded-case circuit breakers. Latter are differentiated by constructional features and are limited to 600 volts. They're used mostly for small motor and lighting applications, see pp 94-95.

Large air circuit breakers are used at voltages as high as 13.8 kv. They are almost always applied as metal-enclosed unit type switchgear, with drawout arrangement, in the 2.4 to 13.8-kv range.

In the voltage range below 600 volts, air circuit breakers are popular as individually mounted units. Individual mounting on bus duct, including ceiling mounting, has grown in recent years. It is often a convenient way to increase protection on a system with rapidly expanding load. Individually mounted air breakers are available with a variety of enclosures including dusttight, watertight and explosionproof units.

Voltage ratings in medium-voltage area are 2.4, 4.16, 7.2 and 13.8 kva. Corresponding continuous current ratings are 1200 and 3000 amp available in breakers designed for each of the nominal voltage ratings.

Momentary current ratings vary more widely: 20,000, 40,000 and 60,000 amp at 4.16 kv; 40,000 and 69,000 amp at 2.4 kv; 51,000 and 70,000 amp at 7.2 kv; 20,000, 35,000, 40,000 and 60,000 amp at 13.8 kv. Interrupting mva ratings run accordingly: 75, 150, 250 mva at 4.16 kv; 100, 150, 250 mva at 2.4 kv; 250 and 500 mva at 7.2 kv; 150, 250, 500, 750 and 1000 mva at 13.8 kv.

Air-break circuit breakers in medium voltage range have advantages of simplicity, compactness and lack of equipment such as is required to provide oil or compressed air for circuit interruption in types of circuit breakers previously discussed for this service. Since they are used in metal-enclosed unit switchgear in conjunction with low-voltage air-break protective devices, there are advantages derived from uniformity.

Circuit breakers are used for motor-starting duty with certain limitations. Principal drawback is repetitive duty which breaker must withstand. If motor is started infrequently, advantage may be taken of the economy of using a protective device for the starter. Contactors designed for motor starting are capable of much more severe repetitive duty and will be more economical if motor is started frequently. When circuit breakers are applied on repetitive reclosing cycles the interrupting rating of the breaker should be derated.

In the low-voltage area, air-break circuit breakers have all but taken over. Advantages listed for medium-voltage breakers apply to low-voltage breakers, too. In low-voltage range, simplicity of maintenance is especially important, for often smaller plants will not have personnel trained to properly service oil or compressed-air equipment. Interrupting ratings run from 15,000 to 150,000 asymmetrical rms amperes.

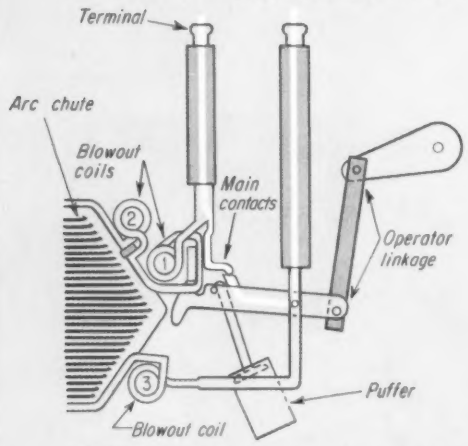
Nominal voltage ratings are 240, 480 and 600 volts. Continuous current ratings run from 15 to 4000 amp in several proportionate steps. For example: 15, 20, 30, 40 amp . . . 2500, 3000, 4000 amp. Low-voltage air breakers usually have built-in overcurrent relays. These have two settings – a *long-time* or a *short-time* delay setting – as well as an instantaneous trip. A few designs combine all three.

Long-time delay carries one to six times continuous current for periods adjustable from two or three minutes to a few seconds. It's intended for overloads and high-resistance short circuits.

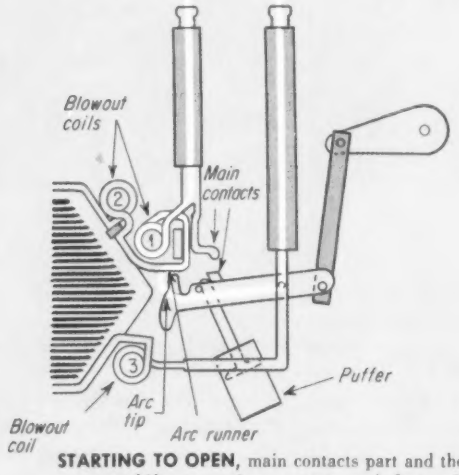
Short-time delay is adjustable from about 3 to 12 cycles for purposes of selectivity. The instantaneous trip opens the circuit immediately on faults of 6 to 15 times continuous current.

Network protectors are air circuit breakers with an operating mechanism and relays specifically designed for network duty, see p 77. A high degree of automatic operation is required and the units must be as self-contained as possible. Usually, backup protection is provided by fuses.

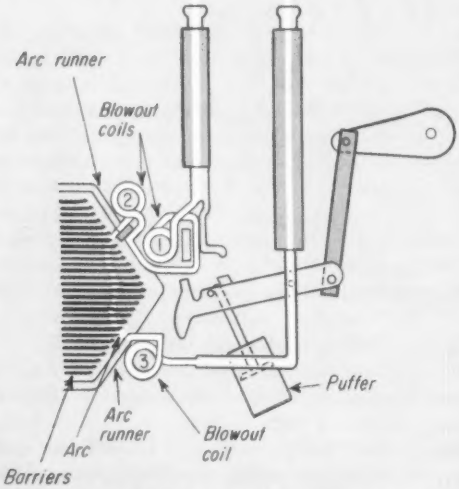
How air circuit breakers work



CLOSED POSITION of breaker with current flowing through the studs and the main contacts



STARTING TO OPEN, main contacts part and the current shifts to arcing contacts and first coil



INTERRUPTION occurs as arc is driven against arc splitters by magnetic action of blowout coils

Air-break circuit breakers generally have a sensing device (series overcurrent coil), relays, actuating mechanism and interruptors all in one unit, though this isn't necessarily the case. Frequently they are operated manually, but automatic and remote electrical operation is common.

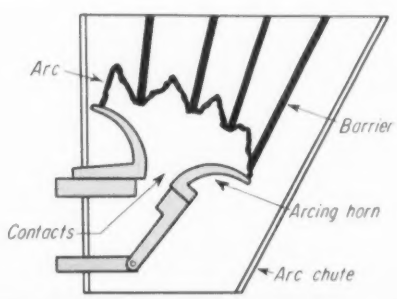
Interrupting capacities of air-break circuit breakers have gone up in recent years as engineers continue to design improvements into the fundamental interrupting device. This fundamental device consists of two contacts that separate in air to interrupt the circuit, as in the familiar contactor, see sketch below. Here, the contacts are partially opened.

When arc is drawn as contacts part, arc is intense; but as arc is drawn farther out when contacts separate more, there is increased cooling and deionization by diffusion. Simplest contactor depends on distance only to "stretch" the arc and interrupt it. However, modern high-capacity circuit breakers use means to assist the air in extinguishing the arc. Arc horns are useful in getting the arc to stretch. The arc is initiated at the inner ends of the horn-shaped contacts. Electromagnetic effects, convexion air currents and natural buoyancy of the arc tends to force the arc upward. The center portion of the arc moves faster than the ends where it touches the contacts, further helping to elongate it to point where it snaps.

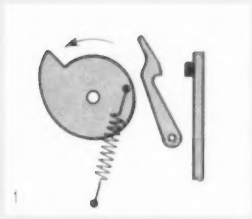
Since space is at a premium in today's switchgear, arcs are confined in smallest possible arc chutes. To further assist the stretching effect in cooling and extinguishing the arc, arc barriers are built into the arc shoot perpendicular to the length of the arc. They are arranged in such a way that (1) the hot gases can escape and (2) the arc tends to move up between the barriers and get split into "pieces." (For this reason they're also called arc splitters.)

In larger breakers, the barriers or arc splitters are usually made of insulating material of a refractory nature. When the arc moves against the edges of these barriers, the edges restrain further movement of the arc at the points where it touches. Meanwhile, the sections of the arc between the barriers are free to loop into the spaces where they are continued to be stretched. The arc is cooled at the points where it touches, is deionized and extinguished. Arc barriers are usually V-shaped to guide the arc into the center of the barrier.

Natural forces tending to move the arc against the barriers usually aren't strong enough, so it's customary to

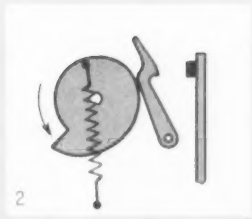


INTERRUPTION of arc in typical air breaker is accomplished when moving arc strikes barriers. Arc spreads out to horn tips



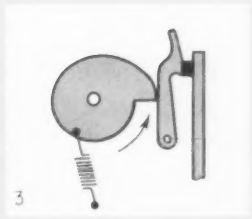
ENERGY IS STORED

Moving handle doesn't move the contacts at first but stores energy by expanding powerful spring as the cam is rotated



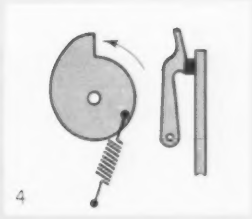
ENERGY IS RELEASED

At crossover point spring begins to release its stored energy and causes the cam to rotate independent of the handle



THE CONTACTS ARE CLOSED

The cam rotates, driven by the spring, and closes the contacts forcefully. Contacts latch closed as cam continues to turn



MECHANISM IS READY

After contacts latch in, overtravel carries cam back to initial position. When contacts drop out, cycle can be repeated

employ *blowout* coils to greatly strengthen the magnetic forces acting on the arc. The current to be interrupted, or a definite portion of it, flows through the blowout coils and produces a magnetic flux that is proportionate to the magnitude of the arc. The blowout coils are located where they can magnetize iron plates, or "poles" on either side of the arc chutes. The arc produces its own magnetic field which interacts with the blowout field and drives the arc against the barriers. Generally, the construction is such that the blowout coils are not energized until the arc is drawn.

In smaller breakers and some large ones, the arc barriers may be metal plates instead of insulating material. In this case the action is somewhat different. The arc moves back between the plates, splits into small sections with the current flowing through the metal plates between the sections of arc. The arc is cooled as it moves; cooling and resistance effects at metal surface tend to deionize the arc and extinguish it. Numerous plates are used and spaced as close together as practical without unduly restricting ventilation.

Construction of typical modern air-break circuit breaker is shown on facing page. Top sketch shows the breaker closed, as it would be in normal operation or at the exact instant that a fault occurs. Almost all of the current is carried by the main contacts which are made of silver-plated copper or silver alloy to insure low resistance. Main contacts open first when breaker trips, center sketch, and fault current flows through arcing contacts. As arcing contacts open, arc is drawn between arcing tip of moving contact and the stationary *arc runners*. Path of current is now from stud on left through blowout coil No. 1, through the adjacent arc runner, the arcing tip and back through the conducting path in the mechanism to the right stud.

Arcing tips are inserts of some durable metal like tungsten that are welded to the contact. They are required to carry total current only during interruption.

Action of blowout coil No. 1 forces arc off arcing tip of movable contact, and arc now spans between the upper and lower arc runners, bottom sketch. Blowout coils No. 2 and 3 are now in series with the circuit, and powerful magnetic action drives the arc into the closely spaced insulating barriers where it is extinguished. Sequence of these operations is very fast.

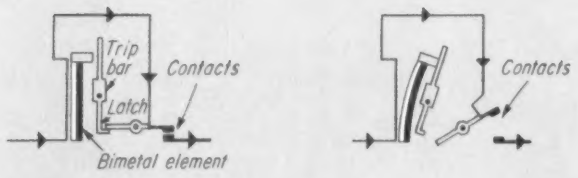
To reduce arcing time still further and insure clean fast interruption on low currents, larger air breakers are generally provided with a booster cylinder or *puffer*. This is a piston and cylinder arrangement which operates on the opening stroke of the breaker to direct a blast of air across the contacts and into the arc chute. In type shown in sketch, the piston rod is hollow and carries the blast of air to the contacts as they part.

Operating mechanism of air-break circuit breakers has come in for close engineering scrutiny as ratings climb. Stored energy, in the form of a spring under tension, compression or torsion, isn't a new idea to circuit-breaker manufacturers; but in recent years they have reappraised its advantages and some have put it to work in their new designs. Principal use is in reclosing where strong fast thrust, independent of man's manner of closing the handle, is needed. If closing in on a fault, such action can prevent damage. Same effect can be achieved, of course, with a powerful solenoid. But advocates of stored-energy methods claim greater simplicity, dependability, low control power requirements.

Simple sequence of operation is shown above. With automatic control a small motor charges the spring. Built-in sensing devices and relays often are combined in a series-coil electromagnetic attraction device. The adjustable time delay is obtained with a sealed, positive-displacement oil piston mechanism. Thermal elements may be used in combination for the long time delays in smaller size breakers, as is typical in the molded case types, pp 94-95. Relays are calibrated in such a way as to make it easy to adjust them for the small time differentials required.

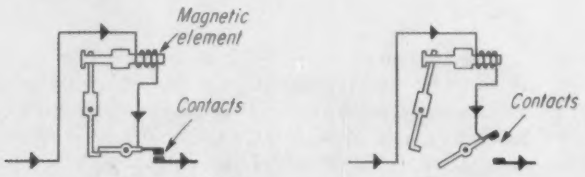
Molded-case circuit breakers lead low-power field . . .

Today's four kinds of molded-case breakers



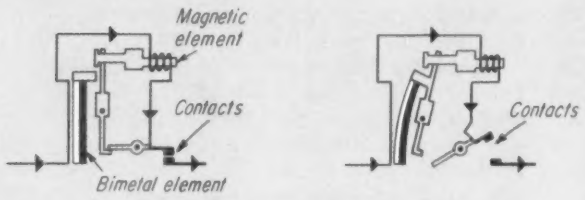
Thermal

Mechanism holds contacts closed by latch. Thermal element is bimetallic strip that is heated in proportion to line current and inversely in proportion to time. When the bimetallic strip bends sufficiently it trips the latch



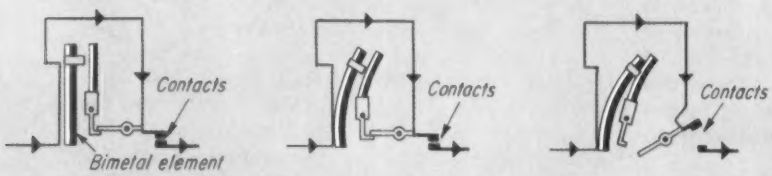
Magnetic

Latch is tripped by action of small electromagnet. Inherently an instantaneous device, inverse-time delay can be obtained by additional mechanism such as dashpot or geared arrangements. Magnets are quite small



Thermal-magnetic

Thermal element serves for long time delays, trips latch after overload has been carried as long as is safe. Magnetic trip is instantaneous if short circuit occurs. This combination is the typical arrangement today



Ambient-compensating

Action is same as in thermal-magnetic type, except that a second bimetal element is added; it's interposed between first element and trip latch. Both elements bend with ambient heat, but only first responds to current

Molded-case circuit breakers are a type of air-break circuit breaker characterized by a molded-plastic case. Extreme compactness is one of their most important features. The smaller sizes are generally riveted together and can't be repaired, but larger sizes may be opened.

Their chief application is for protection on small motors, lighting and appliance circuits. To a great extent they have replaced fuses for these services. They are, however, built as high as 800 amp in special sizes for distribution feeders and heavy equipment circuits. Voltage ratings are 120, 120/240, 240 and 600 volts.

Molded-case breakers are built in six frame sizes representing maximum ratings: 50, 100, 225, 400, 600 and 800 amp. Intermediate ratings are based on continuous current ratings of relays. In other words, a 10-amp breaker and a 50-amp breaker will have the same frame size. Interrupting current ratings run from 5000-amp asymmetrical for a 240-volt 10-amp breaker to 50,000 amp asymmetrical for a 240-volt 800-amp breaker.

Four kinds of molded-case breaker action are shown at left. Most typical of these is the thermal-magnetic type without compensation for ambient temperatures, although others are popular, too. Long-time and instantaneous trips adapt breakers to overload protection as well as fault protection. Magnetic trips in some models are not adjustable; others have adjustable magnetic trips to allow for co-ordination.

Typical molded-case breaker is manually operated by a toggle type handle — the breakers bearing a resemblance to toggle switches. When breaker trips, handle assumes a position that indicates it is tripped and must be reset. Resetting is usually accomplished by putting the handle in the *off* position before reclosing it in the *on* position. Operating mechanisms are trip free. Breakers come in one, two, three and four poles. Molded-case breakers are used in a variety of enclosures, including explosionproof, and actual breaker handle may be actuated by different types of handles external to the en-

. . . can team up with current-limiting fuses for bigger jobs

closure. Breakers may be ganged, if desired. Solenoid-operated or motor-driven mechanisms are available to provide remote control.

Modifications of molded-case breakers are numerous in order to make them as versatile as possible. Accessories are available to do certain jobs. Leading modifications are: (1) A shunt-trip device operated by a solenoid for electrically tripping the circuit breaker from a remote point in plant. (2) Mechanical interlock between two adjacent breakers that permits one breaker only to be on at a time. (3) Undervoltage release that trips the breaker automatically if there is severe voltage dip or loss of voltage. (4) Alarm, audible or visible, that warns when breaker has tripped automatically. (5) Auxiliary switch that synchronizes other equipment with the *on-off* positions of the breaker. (6) Mounting conveniences such as drawout construction and rear terminal studs. (7) A handle-locking device that holds breaker in *off* or *on* position.

Current-limiting fuses can be used to back up molded-case breakers where the available short-circuit current would otherwise be beyond the capacity of the breaker. This practice has become important in recent years because of substantial increases in available short-circuit current in low-voltage areas.

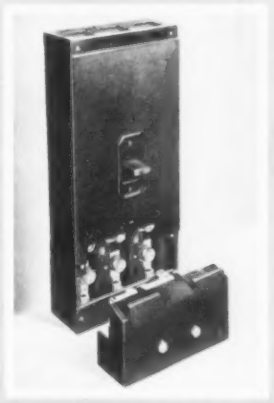
Current-limiting fuses are combined with molded-case breakers in two ways: (1) in an integral breaker construction or (2) separately mounted but co-ordinated as far as interrupting characteristics are concerned. (Fuse characteristics are discussed in pp 96-98.) Both types of breaker-fuse combinations can be used on circuits with up to 100,000-amp available short-circuit current.

Breakers trip on their thermal and instantaneous settings and the fuses blow only if magnitude of fault current approaches value which would damage breaker. Curves at lower right show co-ordination of typical breaker and fuse. Notice that there is a range of current-limiting fuse which can be used; a minimum fuse rating which will co-ordinate, and a maximum rating which will protect the breaker. When fuses within this range are used, the breaker will always trip on both overloads and short circuits.

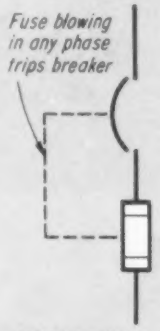
Although the fuse is current limiting, when co-ordinated properly its let-through current is sufficient to trip the breaker. This is important in order to prevent single-phasing and consequent damage to motors and other equipment should only one fuse blow. Be sure to follow manufacturer's co-ordinating instructions so as to get proper matching of fuse and breaker.

In integral-type combinations the current-limiting fuses have a spring-loaded plunger that is expelled when the fuse blows. This plunger acts on a common bar in the breaker mechanism. It trips the breaker, causing all poles to open and thus it prevents single phasing. This type cannot be reclosed when the breaker trips as a result of a fuse blowing because the extended plunger prevents resetting of the breaker. The operator is warned that a major fault has taken place.

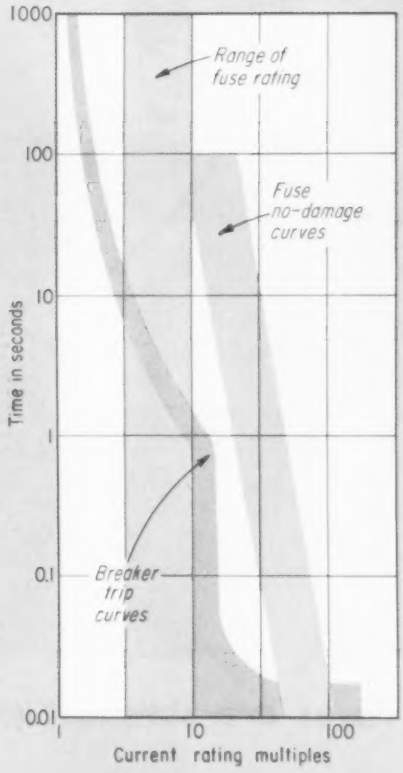
Breakers and fuses are co-ordinated



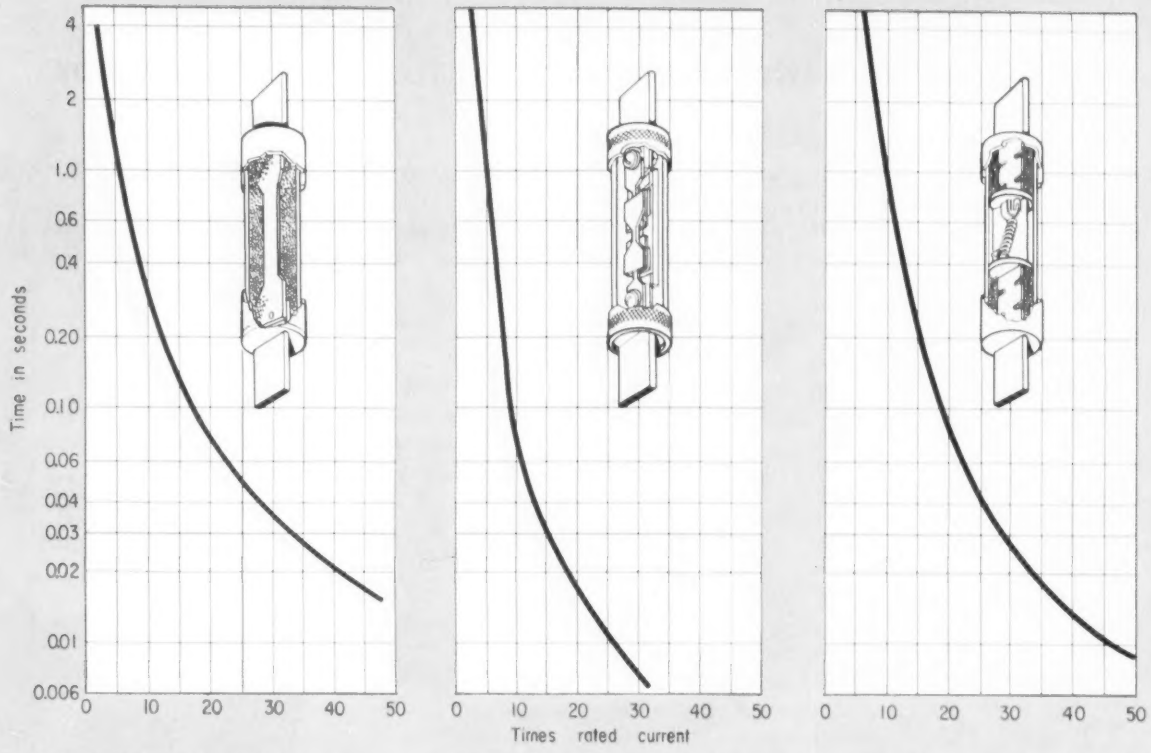
INTEGRAL fused breaker



SINGLE-PHASE FAULT trips the breaker, opens all phases



TIME-CURRENT CHARACTERISTICS of typical molded-case breakers and current-limiting fuses



ONE-TIME FUSE has fairly short inverse time delay. When it blows it's discarded

LAG FUSES have longer time delays to carry brief overloads. Links are renewable

DUAL-ELEMENT FUSES combine long-time elements for overloads, fast fuse for faults

Fuses are simplest protectors

Fuses, unlike circuit breakers, combine functions of fault detection and interruption in one element. They are not adjustable and co-ordination depends on selection of fuses with proper characteristic curves. There is a variety of fuse characteristics available today.

Fuses, like other protective devices, must carry rated load current continuously, and must safely interrupt the fault current for which they are intended. Main fuse parts are (1) fusible element or link (2) arc-quenching mechanism, usually a powder surrounding the link assisted by mechanical features of the link, and sometimes a spring (3) enclosure and connectors, capable of containing mechanical stresses of the fault current. Inverse-time characteristics are natural to fuses. Design of links and composition of fusible metal pinpoints time-current values.

At 600 volts and below, familiar fuses are the *one-time* or NEC fuse, the *renewable-lag* fuse and the *dual-element* fuse, shown above.

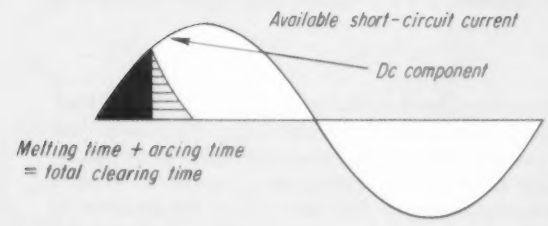
One-time fuses are simplest and least expensive fuses but have shortest time delay. If used on circuits with brief but heavy overloads, such as motor starting, they may have to be selected too high to give desired protection.

Renewable-lag fuse introduces more time delay by special construction of the link. Typical lag link has narrow and wide element sections in series. Wide portions act as heat-storage compartments. Under short-time overloads these sections absorb heat from surrounding thin spots, preventing the fuse from blowing. If overload continues, heavy areas can't absorb all the heat and the reduced sections melt. On short circuits the thin sections melt immediately because the heavy sections can't draw off the heat rapidly enough.

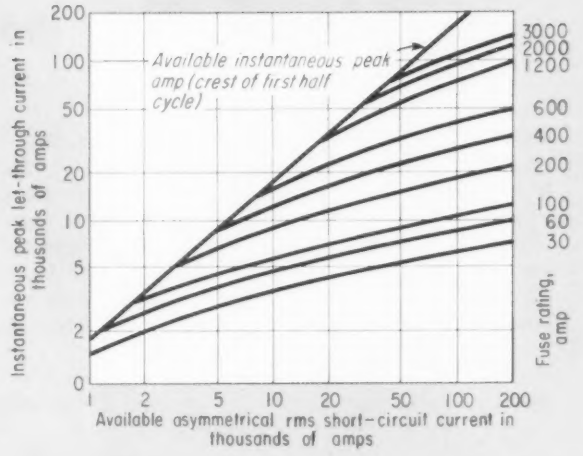
Dual-element fuses make use of fusible metals with different melting points. Fault current is interrupted rapidly by fuse link similar to conventional links. Overloads are handled by a different element, such as a "solder pot" under tension of a spring. Fusible material of this element has lower melting point than that of fuse link, but large mass takes time to heat up. Overloads of short duration don't melt solder, but if they are sustained solder softens and spring pulls contact loose, opening the circuit. Thus, relatively long delays are possible.

Above 600 volts leading types are *expulsion fuses* and *current-limiting fuses*. (Latter find their widest application in low-voltage circuits, however.) Typical expulsion fuse, shown on p 99, has fusible element held under tension, and contact is maintained through a plunger. When fuse element melts, plunger draws the arc through the

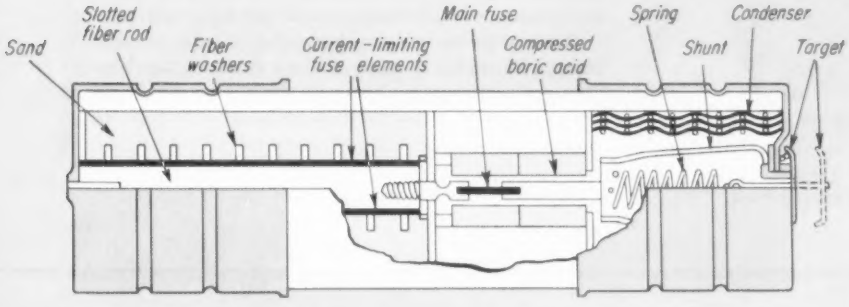
Current-limiting fuses cut off fault current before it reaches peak value



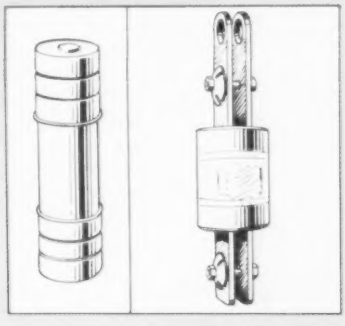
INTERRUPTION is complete in ½ cycle, but fault current rise is checked as fuse melts before peak; diminishes during arcing time



LET-THROUGH CURRENT of typical current-limiting fuses. Let-through current is in peak-amp; available in asymmetrical rms amp



CONSTRUCTION of one type of h-v current-limiting fuse. Fast fuse elements limit current rise, slower element blows during arcing time of first, releasing spring and target



TYPICAL current-limiting fuses are fitted for connectors that withstand high currents

tube at high speed. Arc causes compressed boric acid or other compound to generate high-pressure gas which in turn extinguishes the arc. A condenser, frequently made of wire gauze, absorbs energy from the expanding gas and cools the fuse. Mufflers reduce explosion noise. Another kind employs a high-strength glass tube filled with an arc-quenching liquid such as carbon tetrachloride (which, incidentally, does not freeze or congeal.)

High-interrupting capacity fuses must be capable of interrupting large fault currents. Current-limiting fuses lead this class for low voltage, and are being applied in higher ranges, too, along with expulsion fuses just described. Dual-element low-voltage fuse has a relatively high interrupting capacity.

Current-limiting fuses, shown above, in addition to interrupting fault current, serve to prevent its rise to maximum possible value as determined by impedance of the circuit. This has led to their widespread adoption in recent years, especially in low-voltage areas where load has grown tremendously. Sometimes there is no other practical way to cope with available short-circuit current.

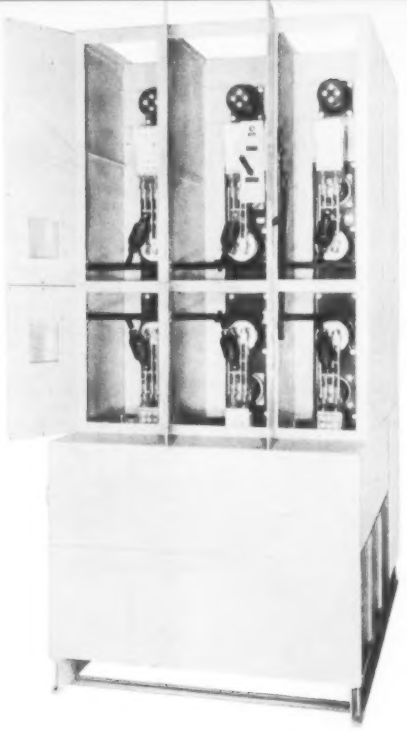
In 600-volt class, current-limiting fuses are rated up to 5000-amp continuous, applicable to circuits with 300,000-amp rms asymmetrical. These large ratings find use where utility supplies power from low-voltage network. Lower ratings are being used increasingly as backup protection for molded-case circuit breakers, p 95. They're getting attention for protection of busway, too.

In higher voltages (up to 34.5 kv) they are used with load-interruptor switches, p 98. Top continuous rating is 200 amp. This fuse interrupts 60,000-amp rms asymmetrical at 4.16 kv. Choice of ratings of high-voltage current-limiting fuses is rather narrow at present, but interest in this application is on the increase.

Fuse element, made of silver, is surrounded by fine quartz sand. This construction produces fast-acting fuse. Fuse element melts in ¼ cycle or less, before current has time to rise to maximum value. Arc resistance increases, limiting current, until the current is zero when the arc is extinguished at about ½ cycle.

Construction details vary with maker and voltage class. Fuse, shown above, is for high-voltage applications. The additional series fuse link starts to melt almost simultaneously with the silver link, but it's the silver link which stops current rise by introducing long, thin high-resistance arcs in series with short circuit. The series link guarantees opening of circuit by method similar to expulsion fuse. At same time it extends a target, indicating fuse is blown.

Interruptor switches with



INTERRUPTOR SWITCH, air-filled, has an incoming line selector and primary fuses

In recent years fused switches have been widely adopted for protection of incoming high-voltage supply lines, and their acceptance for main secondary feeder protection is growing. Advantages of these switches are simplicity, low maintenance and lower first cost than circuit breakers. It should be recognized that fused switches can't give the same degree of protection that circuit breakers can, but in many plants high-grade protection isn't necessary. If faults are expected to be infrequent (as indicated by experience or nature of plant's production process), let's say once in five or ten years, you may not be justified in having a circuit breaker "waiting" for a fault. On the other hand, if faults are liable to occur more frequently, cost of fuse replacements and downtime while fuses are out can quickly override economies of initial investment.

Most popular primary protective switches are the air-insulated load-interrupting devices that use expulsion or current-limiting fuses. These switches are metal enclosed and some models are built on drawout principle. Interruptor switches are usually designed to interrupt load

Current-limiting reactors, lightning arrestors, grounding

So far the protective equipment which we've been talking about has been interrupting devices. But other equipment can be of value in protecting the system. Let's look at some of them.

Reactors and current-limiting bus are used to deliberately introduce reactance into a circuit to limit the available short-circuit current or ground-fault current. Some of their applications in the system were described in pp 78-79. Since they inevitably produce some voltage drop, they should be avoided in parts of the system where they will be continuously carrying load current. However, when redesigning an old system (and sometimes in designing a new one), they provide a means for keeping fault current down to magnitudes where it can be handled economically. As grounding reactors and for tying generators to synchronizing bus, they don't carry load current continuously. In other applications some engineers regard them only as stop-gaps.

Current-limiting reactors are simple devices, consisting principally of an air-core coil held strong against the mechanical stresses of current surges. Frequently the coils are cast in concrete. Sometimes a resistor is used in shunt with a neutral-grounding reactor to prevent excessively high transient voltage from appearing at the neutral. These are non-linear resistors made of a material which offers a very high resistance to normal voltages and a low resistance to high-voltage surges. Current-limiting bus is bus spaced in such a manner that its reactance is increased to a predetermined value. Lengths of this bus can provide reactance at transformer and generator leads.

Lightning arrestors provide a high degree of protection against lightning surges and high-voltage switching surges on supply lines. They're a good investment for any plant supplied by long overhead lines. They're connected at the primary side of the system's primary substation.

Another use for lightning arrestors (surge arrestors) is to protect rotating machinery against voltage surges. Insulation of rotating machinery is not as well suited to withstand electrical and mechanical stresses as are stationary equipment such as transformers. Surge arrestors, frequently in combination with capacitors, are connected to the leads of the machine close to the machine itself.

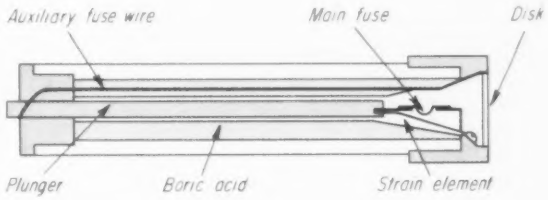
Lightning and surge arrestors can be fairly complicated in their internal construction, but are not difficult to install. The arrestor presents a very high resistance at normal voltages and a low resistance at surge voltages; it is in effect a non-linear resistor. The active part is encased completely in a porcelain insulator designed to prevent breakdown of an external path shunting the arrestor. Ground connection of the arrestor should have a low resistance and low surge impedance. When an arrestor is connected

power fuses will often fill the bill

(continuous rating) current, but some are intended only for magnetizing-current interruption. To provide better closing against full momentary current in case of a fault, there is usually a stored-energy mechanism so closing speed is not dependent on the operator. Springs are charged by a ratchet mechanism and discharged from a handle on the front of the enclosure. In this way the switch will close and latch in against maximum fault current passed by the fuses.

Interrupting requirements of the switch are maintained within safe limits by the proper selection of fuses. Time delay interlocks are built in to prevent reopening the switch after closing until a sufficient period has elapsed to allow the fuses to blow if a fault exists. This prevents the operator from opening the switch on a current in excess of the switch's interrupting rating.

Fuse switches can be co-ordinated with other protective devices depending on their characteristics. In general, fuses can't provide as close co-ordination as circuit breakers. Fuse switches are available that have a rapid-switchover feature; if fuse blows a second set can be cut into the circuit, thus reducing shutdown time on transient faults to minutes or seconds. However, if second set of fuses blows, power can't be restored until fuses have been replaced. Current-limiting fuses are favored today for many applications, although other types of power fuses are also commonly in use in load-interruptor switches. Selection will depend on the conditions of the system.



HIGH-VOLTAGE POWER FUSE of type frequently used with air-filled interruptor switches. Boric acid forms the arc-quenching gas

devices, transfer switches belong in protection picture

between a phase and ground on a 3-phase system, the voltage rating of the arrestor must equal or exceed the maximum power voltage that the system produces under normal or abnormal conditions, including fault conditions.

Grounding equipment for system neutral grounding was mentioned on p 78. Two types of grounding transformers are in general use where it is desired to ground a system whose power transformers don't provide a neutral. They are wye-delta transformers and zigzag transformers. Zigzag transformers have no secondary windings; their coils are connected so impedance to 3-phase currents is high. When there is no fault on the system only a small magnetizing current flows. However, the transformer impedance to ground is low.

When used strictly for producing a neutral for grounding, reactance of transformer should be selected to meet desired current-limiting conditions. That is, transformer may be connected through a resistor to ground, or may itself provide reactance for reactance grounding. It must be remembered that grounding transformers are used only when it is uneconomical to modify an existing system to include wye-connected, load-supplying transformers of sufficient capacity to handle ground-fault currents.

A ground-fault neutralizer is a device used to get resonance grounding. It provides an inductive component of current in a ground fault that is substantially equal to the rated-frequency capacitive component of the fault current and neutralizes it.

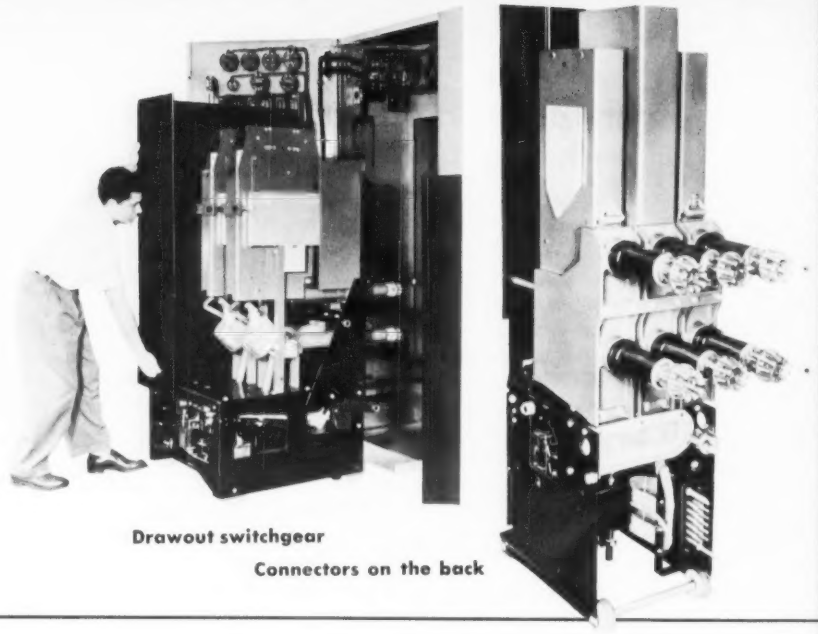
Automatic transfer switches come into the protection picture in those plants where continuity is so important for critical processes that the cost of complicated throwover systems is justified. Referring to secondary selective system, p 76, automatic transfer can be used to disconnect a deenergized secondary bus quickly from its transformer and connect the bus to the corresponding energized transformer. The automatic transfer can be designed to reconnect the system to normal when proper voltage is restored to the transformers that were out of service. Shifting large blocks of power in this manner can cause many problems.

Another use for automatic transfer is to shift the most critical loads to an emergency supply, to establish lighting, fire pumps, etc.

Construction of transfer switches resembles motor-starting contactor. Contacts are intended to interrupt load current and starting surges, but not to interrupt fault current. Transfer switch must be backed up by fuses or circuit breakers. Transfer time is in the neighborhood of one second for typical switches. Intentional delay is sometimes introduced to allow motor starters to drop them off the line, reducing load and preventing damage to motors when reclosing.

Drawing out the breaker

Popular feature of today's metal-enclosed switchgear is ability to draw out the circuit breakers, fuses or switches as units. Components are then readily accessible for maintenance. Interlocking provides safety; breaker must be in open position before it's removed. Most switchgears provide a test position in which control circuit operates but main contacts aren't energized. Power and control connect in place by plugs



Drawout switchgear

Connectors on the back

Modern metalclad switchgear stresses safety, convenience

Metal-enclosed switchgear has virtually supplanted open or panel type switchgear in the voltage ranges which we've been discussing. Its advantages are many.

Metal enclosures protect equipment from damage by foreign objects. Dirty or corrosive atmospheres are less likely to get at vital parts. And, there's much greater safety to personnel. Live parts are covered and effective interlocking is provided to make sure parts are de-energized before they are accessible. It's easier to build in safety features at the factory than to design them in the field.

It is simpler to specify metal-enclosed switchgear; all manufacturers have one or more "standardized" lines. Its dimensions, electrical capacity and performance characteristics are compared readily.

Standardized lines include metal-enclosed components of all types of substations: transformers, capacitors, reactors, control centers as well as the circuit breakers, interruptor switches and fuse compartments. In intermediate and low-voltage ranges, these components can be factory assembled to your specification — limited only by shipping restrictions. Higher-voltage equipment may not actually be assembled into unit substation, but components are matched. To make it even easier, some manufacturers supply guide forms in which you describe the job that is cut out for the equipment. Then, their company's engineers specify the equipment best suited.

Other advantages come from standardization. In general, waiting time for new equipment is shorter. It is easier to install; all framework is assembled or at least prefabricated at the factory. As a rule special foundations aren't necessary. Outdoor units are designed on the same idea, to cut your installation work to a minimum. Structure is rugged and is factory weatherproofed. Base and roof sections permit later additions or rearrangement to suit changes in operational requirements.

Heating elements are supplied to prevent condensation. Growing in popularity is a sizable aisle space inside the enclosure that permits the free interchange of circuit breakers, for maintenance, testing, etc, without interference of adverse weather. Foundation requirements are simple.

Drawout feature is an important advantage of metalclad switchgear, pictured at top of page. Large circuit breakers are rolled out on their wheels after they are disconnected. Connections are plug type; when the breaker is installed and locked in place, the power and control circuits are connected properly without any attention from the electrician. Removing the unit simultaneously disconnects the circuits. Locking the breaker in place is accomplished by either a screw mechanism or something similar. This last few inches of travel that connects (or disconnects) the breaker is horizontal in some models, vertical in others.

Vertical lift design has an elevator which may be manually operated or motor driven. Smaller breakers are mounted in drawers that can be pulled out much like the drawers of filing cabinets. Pulling out the drawers disconnects the circuits. Breaker can be serviced in drawout position, or lifted from the rack that forms the drawer and replaced by another unit. Spare breakers can be kept economically since only a few sizes are needed.

Provision for expansion is another key feature of metalclad designs. Future system growth is taken care of in two ways: (1) The surrounding switchgears have blank compartments built into them. Or, (2) buses are arranged in such a way that additional structure can be added at the ends. These will match identically and line up with the original installation. Since breakers in the same interrupting class are interchangeable, you can often increase breaker size without structural changes. It's a good idea to keep a sharp eye on the future when specifying your switchgear.

How to select protectors for 15 kv through 69 kv

The best way to avoid trouble is to select protective equipment geared to your particular needs. Switchgear is probably the last part of your electrical equipment where performance can be sacrificed to save a few dollars. This is especially true of high-voltage protective equipment because of its location at the beginning of your electrical distribution system. Its shortcomings will be reflected throughout your whole plant. Chart, below, lists features you'll want to know, and gives a rough idea of what jobs different types of protectors can tackle. After eliminating equipment that doesn't fit your needs at all, study manufacturers' literature on all the types you are considering and decide which does the job best. If you're still in doubt, sit down with the manufacturers' engineers and let them explain which equipment will solve your protection problems, and let them tell you why.

In addition to key points in the chart, there are a few general considerations to keep in mind. An important one is expansibility. Interrupting ratings of your high-voltage breakers may be adequate today, but tomorrow may turn out to be a tough bottleneck to plant growth. Modification of system to split load when breakers are outgrown can be expensive. So, power to grow really pays off.

Availability is another factor to be dealt with. Tank type oil circuit breakers, for example, are "stock" items; air-blast breakers are normally made up to 34.5 kv, but can be obtained at 69 kv. If you want low-oil-content breakers you'll have fewer manufacturers to choose from than if you use tank type oil breakers.

The question of protection by circuit breakers or protection by fuses is one you'll have to give serious thought to. Behavior of these two classes of protective devices has been described in preceding pages. Of course, if a high degree of continuity is desired, circuit breakers are your answer. But, as we've mentioned, where incidence of faults is likely to be small, protection can generally be had with the simpler, less expensive fused switch, and they are being widely adopted. Critics of fuses warn of the danger of single phasing, and of the possibility of so-called "dead zones" – values of current above switch's interrupting rating but too low to blow the fuse instantly. Fuse application know-how can minimize these disadvantages.

Protective devices — 15 kv through 69 kv

	Oil circuit breaker	Low-oil-content circuit breaker	Air-blast breaker	Fused switch
Continuous current	600 to 5000 amp	1200 to 2000 amp	1200 to 5000 amp	400 amp max
Interrupting capacity	50 to 3500 mva	2500 mva	3500 mva max	Current-limiting fuses: 1000 mva max
Interrupting speed	8 cycles	8 cycles	8 cycles	Less than ¼ cycle with c-l fuse
Reclosing speed	20 to 45 cycles	20 to 45 cycles	20 to 45 cycles	Manual
Repetitive duty	Depends on duty cycle with reduced ratings	Same	Same	Once
Maintenance	Oil filtering, large quantity. Parts simple but heavy	Oil filtering, small quantity. Parts fairly simple	More complicated parts; compressed air circuits	Very little (fuse replacement if blown)
Accessories	Filtering equipment Usually batteries, possibly transformer and rectifier	Filtering equipment Batteries or transformer and rectifier	Battery or transformer and rectifier	Spare fuses
Location	Outdoors or cubicle	Outdoors or cubicle	Indoors or outdoors	Indoors, outdoors
Operating disturbance	Some noise	More noise	Very loud. Smoke	Expulsion fuses noisy; others quiet
Cost	Lowest for circuit breakers	Next lowest	Highest	Least

Here's what to look for at 600 v to 15 kv

Intermediate voltages are used mostly as primary distribution in the plant, from which large motors may operate. In plants with low-voltage distribution, a voltage such as 13.8 kv may be confined to incoming power supply.

Procedure for selecting protective equipment mentioned in connection with the 15- to 69-kv range is applicable in the intermediate-voltage range. Main difference is a wider selection of protective devices. At higher voltages, the primary substation is usually outdoors and is frequently assembled from separate components. In the intermediate-voltage range the unit substation comes into its own.

In order to take full advantage of metalclad switchgear and unit substations, manufacturers have developed a broad selection of air-break circuit breakers. But, unit type drawout fused switches are available if you're inclined toward fuse protection. Protectors on primary distribution feeders can be expected to operate more frequently than protectors on incoming supply, since they are intended to clear the fault before the source breaker is called upon to act. Keep this in mind when considering fuses in primary distribution.

Fused contactors enter the picture in intermediate voltage range. Contactor takes care of switching operations and is intended for applications where switching is frequent. Relays trip the contactor on overloads and on fault current up to the interrupting rating of the contactor. Fault current of greater magnitude is interrupted by the fuse. Since the fuses are the principal short-circuit protective device of these combinations, they are best suited to applications as the last protector in the circuit rather than as feeder protection. The most common application is as motor starters. The fast operating time of the fuse is a distinct advantage in limiting damage to the motor when the motor's coil insulation fails and a fault occurs.

Protective devices above 600 volts to 15 kv

	Oil circuit breaker	Air circuit breaker	Fused switch	Fused contactor, up to 5 kv
Continuous current	600 to 4000 amp	600 to 3000 amp	400 amp max	400 amp
Interrupting capacity	25 to 1500 mva	50 to 1000 mva	Current-limiting fuses: 750 mva	250 mva
Interrupting speed	8 cycles (changing to 5 cycles)	8 cycles (changing to 5 cycles)	Fraction of cycle with c-l fuse	Same for fuse; contactor slower than circuit breaker
Reclosing speed	Good; not often required	Same	Manual	Good
Repetitive duty	Depends on duty cycle with reduced ratings	Somewhat better	Once	Excellent below fuse rating
Maintenance	Oil filtering; parts simple but heavy	Parts similar to oil breaker, but no oil handling	Very little	Somewhat simpler than breakers
Accessories	Filtering equipment; batteries or transformers and rectifiers if dc controls	Usually ac control circuit	Spare fuses	Spare fuses; otherwise similar to air breaker
Location	Panel in switch room	Indoors or outdoors metalclad	Mostly metalclad	Mostly metalclad
Operating disturbance	None	Some noise, smoke	Expulsion fuses noisy; others quiet	Some noise, smoke
Cost	Next highest	Highest	Least	Lower than breakers

There's a wide selection below 600 v

Low-voltage field covers utilization voltages of most equipment. Modern plant design, where conditions permit, uses load-center distribution. Power is brought to the load center at an intermediate voltage such as 4.16 or 13.8 kv and stepped down to the utilization voltage. Motors and other power loads are preferably operated at 480 volts. Lighting is still mostly at 120 volts, but there is a trend to operate general lighting at 277 volts where fluorescent or mercury lamps are used. Of course there are a great many plants, some of considerable size, that are supplied low-voltage power by the utility.

Capacity of low-voltage protective devices, both continuous and interrupting, covers a wide range. Large air circuit breakers and fused switches, especially those using current-limiting fuses, are favored for source protection and to protect main feeders and busways. Beyond these spots in the system, the molded-case breaker is encountered in almost every application. When combined with current-limiting fuses they are suitable for locations with high fault-current capabilities.

Small molded-case breakers are taking over light-panel service from the one-time fuses formerly in general use. Larger molded-case breakers are being used in place of the fused "safety switch" to protect motor starters in many plants, although fused switch and fused contactors are generally favored for motor protection.

As we pointed out in connection with intermediate-voltage motors, fuses have advantage of quickly removing damaged motor from the line, and being at end of line, continuity isn't affected. Air circuit breakers may be used for motor starting, thus eliminating the starter, and reducing first cost of the installation. In general, if starting is frequent (let's say more than four or five times a day) you'll be better off employing a starter.

Protective devices 600 volts and below

	Power air breaker	Molded-case breaker	Fused molded-case breaker	Fused contactor	Fused switch
Continuous current	6000 amp max	800 amp max	800 amp max	600 amp max	600 amp, NEC; 6000 amp in use
Interrupting capacity	150,000 amp max	50,000 amp max	100,000 amp max	Current-limiting fuses 250,000 amp max	Current-limiting fuses 250,000 amp max
Speed of interruption	2 to 4 cycles	1 to 4 cycles	Fuse in less than ¼ cycle; breaker 1 to 4 cycles	Less than ¼ cycle for c-l fuse; contactor slower than air breaker	Less than ¼ cycle for c-l fuse
Repetitive duty	Depends on duty cycle	Manual	Manual for breaker operation	Frequent, below fuse rating	Once
Maintenance	Fairly simple parts	Practically none	Very little	Somewhat simpler than power air breaker	Very little
Size	Usually larger than molded-case; smaller in some ratings	Generally smallest	Somewhat larger than molded-case breakers	Largest	Next largest
Location	Switchboard, metal-clad, individual	Switchboard, panels, individual	Switchboard, panels, individual, control center	Individual, control center	Switchboard, individual, metalclad
Cost	Highest	Next to lowest	Next to highest	Middle	Least

Where to look in this report for . . .

Circuit breakers	86-95
Air-blast	90
Air-break	91-93
Molded-case	94-95
Oil	88-89
Circuitry	76-77
Fault calculations	80-85
Fuses	96-98
Grounding	78-79
Protection problems	74-75
Selection charts of protective devices	101-103
Switches, fused	98
Switchgear	100

Suggested reading if you want to probe further into . . .

System planning:

Today's Electrical Practice. A 52-p POWER special report published in October 1953 issue. Reprints available

Power to Grow . . . *electrically*. A series of articles from POWER. Reprints available without charge

Electric Power Distribution for Industrial Plants. Publication No. 952. Available through the American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y.

Fault-current calculations:

Industrial Power Systems Handbook, by D L Beeman; published by McGraw-Hill Book Co, 330 West 42nd Street, New York 36, N. Y.

Electric Power Distribution for Industrial Plants. (AIEE No. 952)

Grounding:

Grounding of Industrial Power Systems. (AIEE No. 953)

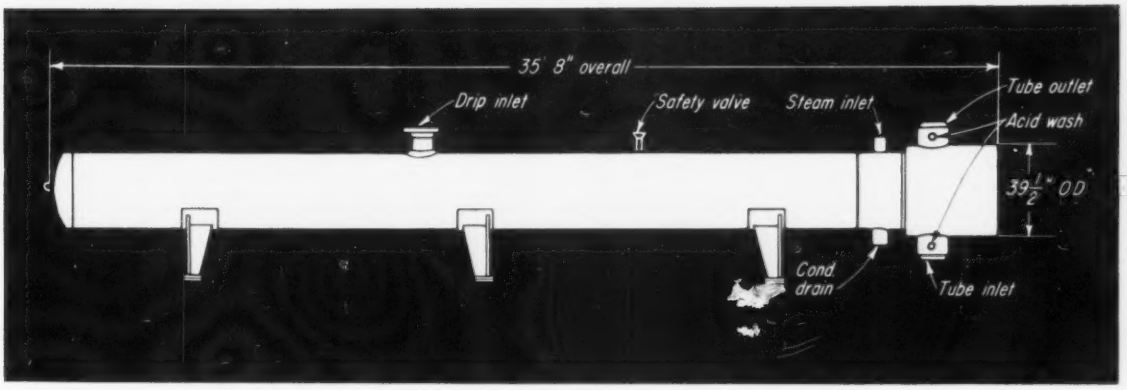
Relaying:

The Art and Science of Protective Relaying, by C R Mason; published by John Wiley & Sons Inc, 440 4th Avenue, New York 16, N. Y.

Applied Protective Relaying. Available through Westinghouse Electric Corporation, Relay Department, Newark, N. J.

Reprints available

Reprints of this 32-page special report are available by writing to Reader Service Department, POWER, 330 West 42nd Street, New York 36, N. Y. There is a charge of $.75 for single copies. Discount on quantities: 10 to 99, 10%; 100 to 999, 25%; 1000 and over, 40%



At CEI's Avon station, pumps will feed boilers through . . .

Feedwater heaters built for 4730 psig

The 250,000-kw unit being added to the Cleveland Electric Illuminating Co's Avon plant is another approach to supercritical pressure use in American central stations. Among the features not previously incorporated in other supercritical-pressure range projects is the feedwater pumping arrangement.

Cost analysis showed that, with a maximum feed-pump discharge pressure of 4730 psig, it would be less costly to use one rather than two pumping stages. Furthermore, savings in pump power in handling relatively cool water (339 F) would be greater than savings obtained from designing the high-pressure feedwater heaters for a lower pressure.

Heaters designed for lower pressures could be used, of course, if a second pumping stage was provided. This would have supplied about 50% of the pumping requirement after the feedwater had left the highest-pressure heater. Added cost of two sets of pumps, as compared with one, was another factor in making the decision for single-stage pumping.

Impact of this decision? For the first time in supercritical-pressure throttle-steam application we'd need a feed heater design wherein feedwater would be raised to full boiler pressure before it enters the heaters.

A cost study indicated an advantage in using two heaters in parallel for each of the high-pressure feedwater extraction stages. Factors studied included: cost of heat exchanger, piping, valves, space evaluation for each arrangement. In using two strings of heaters, it will be unnecessary to provide for by-passing an individual heater. Result will be a significant saving in valving costs.

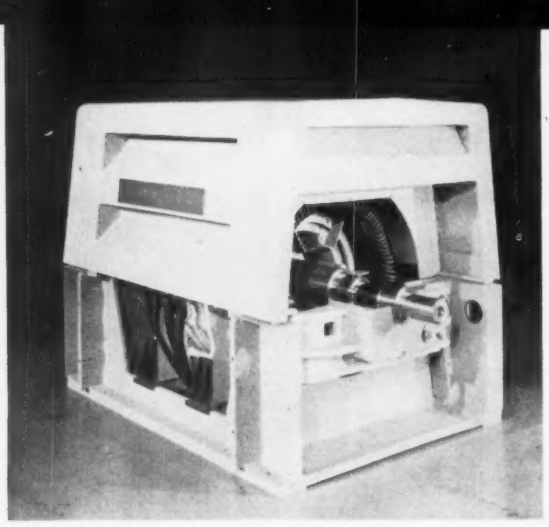
H-p heaters. Four high-pressure heaters, built at Alco Products, Inc's thermal products division plant at Dunkirk, N. Y., are of the U-bend type with integral desuperheaters and drain coolers. Each drain cooler is designed for a 10 F approach to feedwater temperature entering the heater.

Heater tubes are of ⅝-in. OD, 15 BWG minimum wall monel metal. Expanded into carefully drilled and reamed holes, the tubes are welded to the forged-steel tube sheets. In preparation for welding, tubes and tube-sheet holes were cleaned by solvent and live steam. Minimum amounts of a water soluble lubricant used during the rolling operation were completely removed prior to the highly sensitive welding operation.

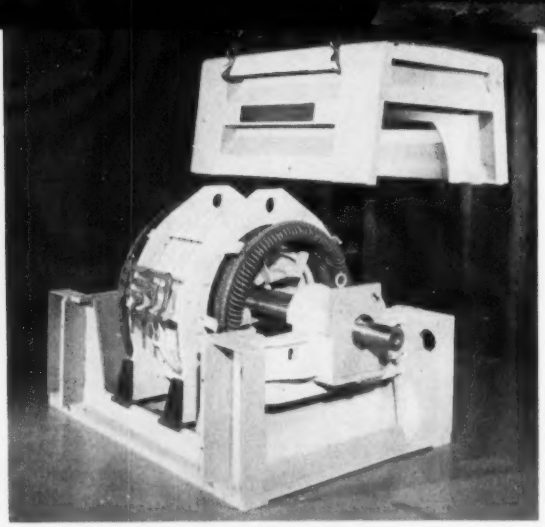
Welding procedure involved a 2-pass technique with small-diameter monel type electrodes. Carefully controlled current and voltage conditions assured minimum dilution with the carbon-steel tube sheet. The longitudinal and girth seams of the shells and the nozzles were welded using qualified submerged-arc and manual metallic-arc procedures.

To provide maximum accessibility to tube-side spaces for maintenance, the water channel covers are sealed with breech-block type closures. Heater shell is welded to the distribution skirt, integral with the channel tube-sheet component, to eliminate a gasketed seal at this point. Flame cutting at a designated cutting line gives access to the shell space to permit removal of the shell. During such a cutting operation a flame deflector plate protects the internals.

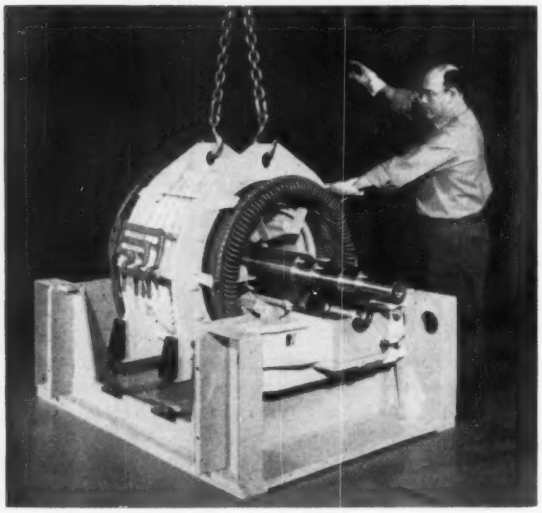
The four high-pressure heaters, though differing slightly in overall dimensions, are typically represented by the drawing, top of page. At rated capability output, this battery of heaters will receive 1.72 million lb of feedwater from the pumps at 4730 psig and about 347 F and deliver it at 560 F to the once-through boiler.



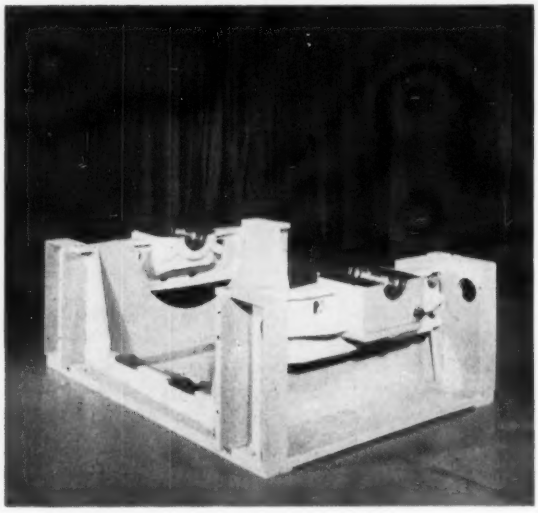
SIDE PANELS, end panels are removed when dismantling, then ...



OUTER ENCLOSURE is lifted off of motor after bolts are loosened



STATOR ASSEMBLY can then be swung out of position, leaving ...



BARE BASE and lower half of the bearings resting on foundation

Motor designers take cue from users

Power men are generally well-aware of the many factors that come into play when selecting, applying and maintaining electric motors. Emphasis, however, is too often placed on one or two electrical requirements. Satisfying a motor's electrical needs means the motor will run. But it's the mechanical considerations — enclosures, bearings, and even insulation—that, to a large extent, spell out how long the motor will perform well.

This month Westinghouse is taking the wraps off their latest designs where the emphasis is smack in the mechanical area. Stripped of adjectives, their newer designs boil down to simple standardization in the large motor range, benefiting both maker and user. For years motor men have grumbled that in the 200- to 4000-hp range the wide variety of types, speeds, enclosures and applications made standardization impractical.

This move on the part of Westinghouse means each motor-frame size in the new package replaces 15 of yesterday's sizes. Six basic enclosures and 30 frame sizes compare to some 450 former frame sizes. Streamlined, auto-assembly type production contrasts with the older series type assemblies. To Westinghouse the benefits are many. Typical: Identification of outline dimensions without calculating a design; justification of precision manufacturing methods with their quality implications; better production scheduling since more parts can be taken from stock.

User benefits are in store, too. Absence of the customary protruding conduit box is a space saver and should speed installation. Once in place, the readily accessible features will be mighty appealing to those directly concerned with routine maintenance and emergency repair.

How F-R lubes affect turbine bearings

By A E TRURAN, Mechanical Design Engineer, General Electric Co

For many years the General Electric Co has been studying the feasibility of using synthetic fire-resistant fluids in place of conventional petroleum oils in steam turbines. Lab studies were made of fluid properties: fire resistance, oxidation resistance, hydrolytic stability, etc. Also, the effect of the synthetics on oil-system materials and generator insulation were looked into. More recently we evaluated the effect of these fluids on bearing performance and the oil system. It is this last study, but in mechanical-drive turbines, we discuss here.

Phosphate-ester fluids show the greatest promise at this time (POWER, May 1958, p 73). We therefore tested a pure phosphate ester, a chlorinated biphenyl phosphate ester, and petroleum turbine oil on a comparative basis using the same bearing parts and test equipment for all the fluids.

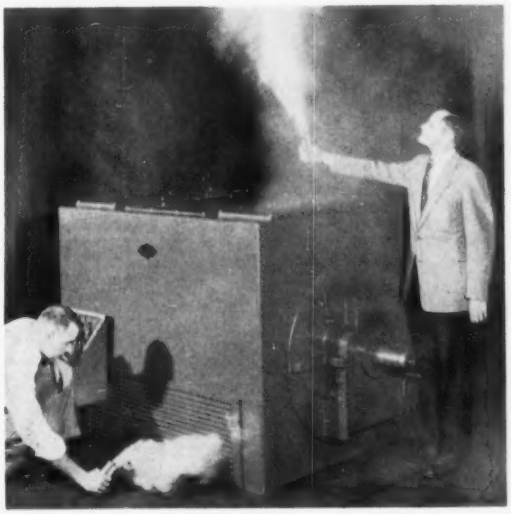
We looked for (1) any reduction in bearing capacity in terms of load (2) increase in bearing temperature at the same load (3) reduction in bearing film thickness (4) differences in required oil flow (5) any increased tendency to foam or leak at oil deflector (6) any malfunctioning of turbine governing system (7) the effects of higher-density fluid, particularly on water condensation in the oil tank (8) how the synthetics shape up under long-time operation.

We set up a single-stage turbine with its complete oil system, to drive a thrust-bearing test machine. However, a separate oil system fed the thrust-bearing rig. Latter scheme was arranged for normal oil-sump turnover rate, while the turbine oil system was set up so the oil-tank volume turned over at a rate three times normal. Same fluid was used in each oil system during each test. This was handled by sizing the oil tank in relation to oil pump. Thrust bearings used were 24 sq in., 7 in. OD. All journal bearings were $2\frac{1}{2}$ in. dia x $1\frac{1}{2}$ in. long.

Instrumentation was provided to give all pertinent oil temperatures, oil flows, oil pressures, plus thrust-bearing film thickness and babbitt surface temperature. To date we have operated the test rig between 5000 and 7500 rpm with thrust loads to the limit of the bearing application range.

Fluids tested were (1) petroleum turbine oil, Shell's *27* (2) a phosphate-ester fluid, Shell *SFR-B* (3) a chlorinated-biphenyl phosphate-ester fluid, Monsanto's *OS-81*. We are now readying to test Celanese *998A*, a chlorinated-biphenyl phosphate ester. (*Continued on p* 176)

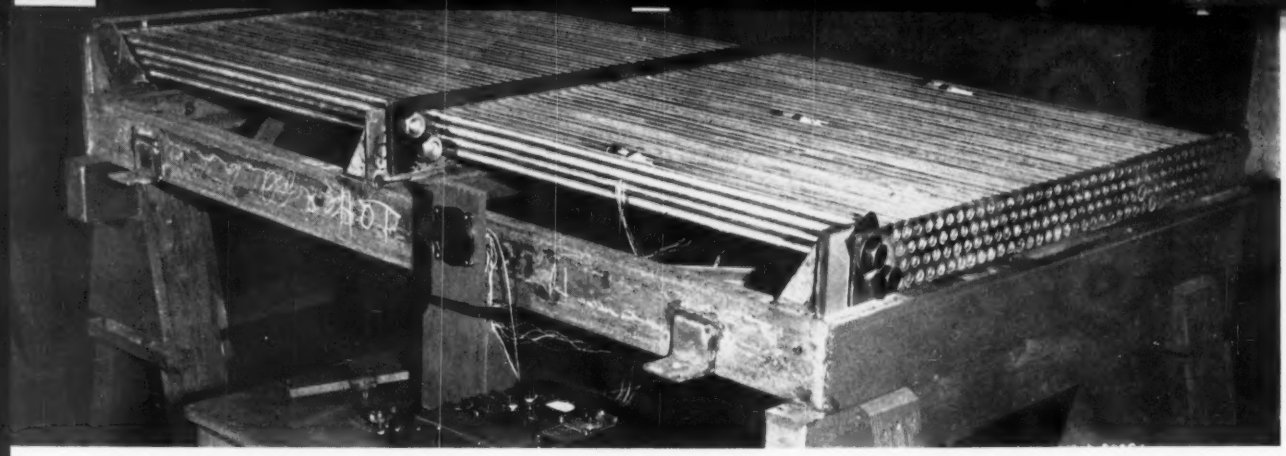
Split-level cooling makes everybody happy



As a motor user, how much do you influence the equipment designer? Case in point can be found in motor, left, recently announced by Electric Machinery Mfg Co (POWER, April 1958, p 158).

Here designer took stock of increased motor sizes for boiler-feed pump operation and concentration of multiple adjacent units. They spelled out a growing problem of heat dissipation and operator comfort. Meeting between user and maker brought out some basic thoughts.

Space is generally at a premium, hence boiler-feed pumps are often placed together in rows. So the ventilating pattern of one motor, as related to its neighbor, becomes of prime importance. Result: Intake air is now drawn in through louvers at bottom, circulated through unit, then discharged through louvers atop motor. Once again the power man got his finger into the designer's pie with good all-around results.



CYCLIC STRESS RESISTANCE is tested with fixed amplitude vibration at natural tube frequency until joint or tube failure takes place

Cyclic stress resistance of welded-rolled joints is excellent. Final article in this 3-part series takes a close look at tests on simulated heat exchangers made by . . .

Welding copper-base alloy tubes

By J F SEBALD and L H HAWTHORNE*

Last installment in April POWER covered Sections II and III of our 4-section condenser-tube welding-test program. From these results we concluded in part that: (1) Welded joints combining admiralty-metal and aluminum-brass tubes with copper-silicon tube sheets have high mechanical strength. (2) Welding admiralty-metal tubes to naval-brass tube sheets gives reduced joint strength with still further reduction typical for the aluminum-brass tubes and naval-brass tube-sheet combination. (3) Rolling plus welding will more likely increase strength of the stronger joints than the weaker ones. (4) Consecutive-sequence tube installation produces more distortion than skip-sequence. (5) Weld distortion increases with heat-energy input per weld and is opposite in direction to distortion from preceding mechanical steps. (6) Weld distortion even though corrective in action is comparatively small for the test assemblies used.

Now let's take up last part of test program. Sections IVA and IVB, dealing with two heat exchangers constructed under simulated manufacturing conditions. Tube-sheet distortion is compared for two different construction sequences. Stresses induced in tubes from both welding and rolling are tabulated. Resistance to cyclic

Heat exchanger tube-sheet distortion

Test	Distortion (in.x10⁶)					Total distortion		Energy input per weld (watt-sec)
	Machine	Swage	Weld	Peen	Roll	Mechanical	Including welding	
IV A	0	+87	−14	−8	+3	+82	+68	17,300
IV A	0	+51	− 4	+0.5	+1.5	+53	+49	17,300
IV B	0	+60.5	0	−2	−1	+57.5	+57.5	17,300
IV B	0	+95	− 3	+7	+2	+104	+101	17,300

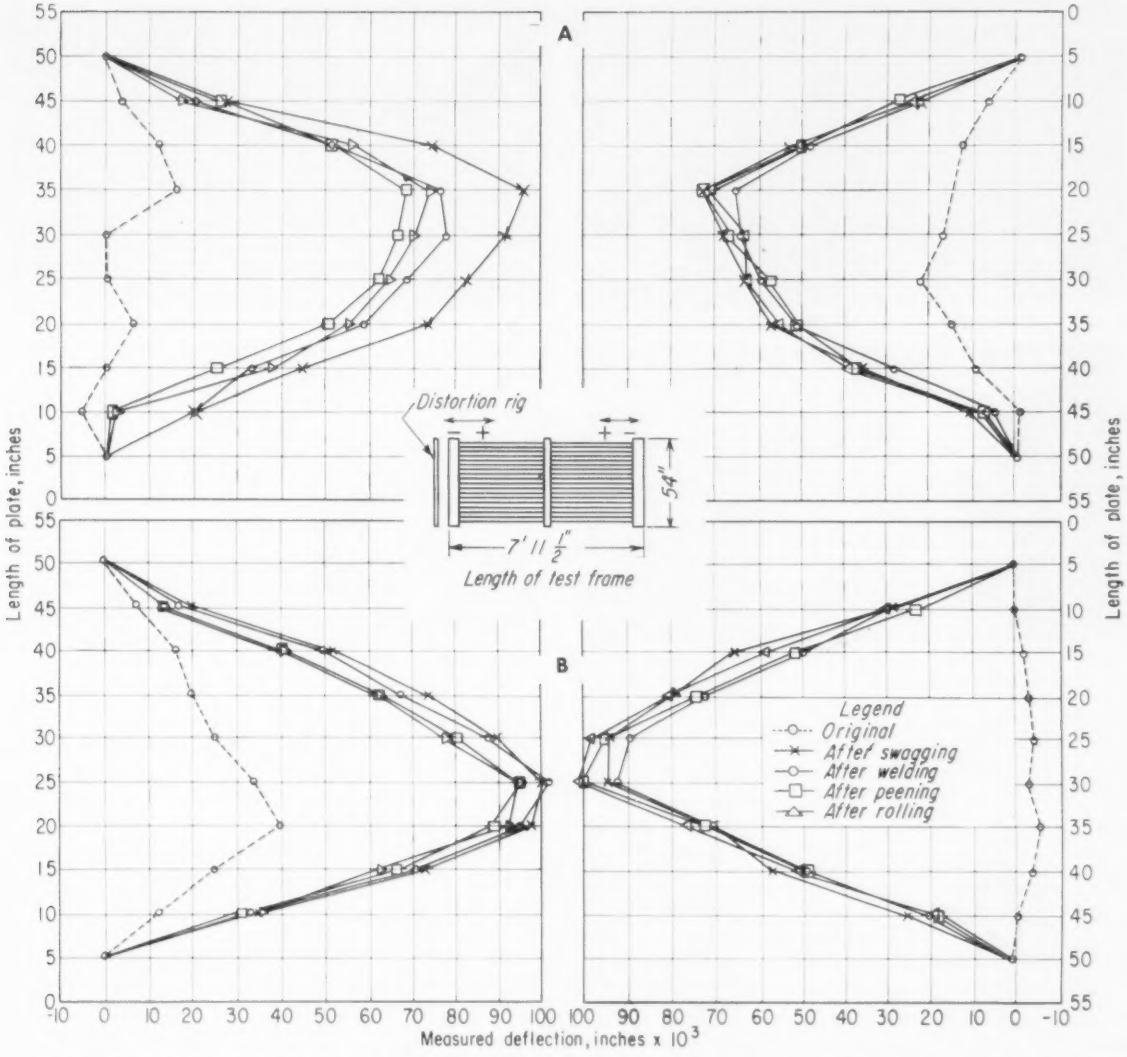
Stress created by welding, peening and rolling

Test	Longitudinal stress (psi) in . . .								
	Tube A after . . .			Tube B after . . .			Tube C after . . .		
	Welding	Peening	Rolling	Welding	Peening	Rolling	Rolling	Peening	Rolling
IV A	+267(U)	+56(U)	−1361(R)	+668(U)	−907(U)	−2468(R)	−175(U)	+334(U)	+4851(R)
IV B	−323(U)	+68(U)	−1913(R)	+146(U)	+643(U)	−2577(R)	+49(U)	+281(U)	+4490(U)

Note—Tubes A and C are located next to fixed edges of tube sheet. Tube B is at center; (R) = rolled tubes; (U) = unrolled; (+) = compression; (—) = tension

*J F Sebald is Chief Engineer, Condenser and Heater Section, Worthington Corporation. L H Hawthorne is Manager, Welding Section, Research Department, Revere Copper and Brass Inc. Article is based on the authors' part in a panel on "Welding of nonferrous tubes to tube sheets," 1957 ASME annual meeting in New York

In this case welding has little effect on tube-sheet distortion



1 Tube-sheet distortion from swaging is opposite in direction to that observed in Sections II and III. Weld distortion is zero for one tube sheet, negative for the other three. Total average distortion in Part B *below* is slightly more than in Part A *above*

stress in welded-only joints is compared to those both welded and rolled.

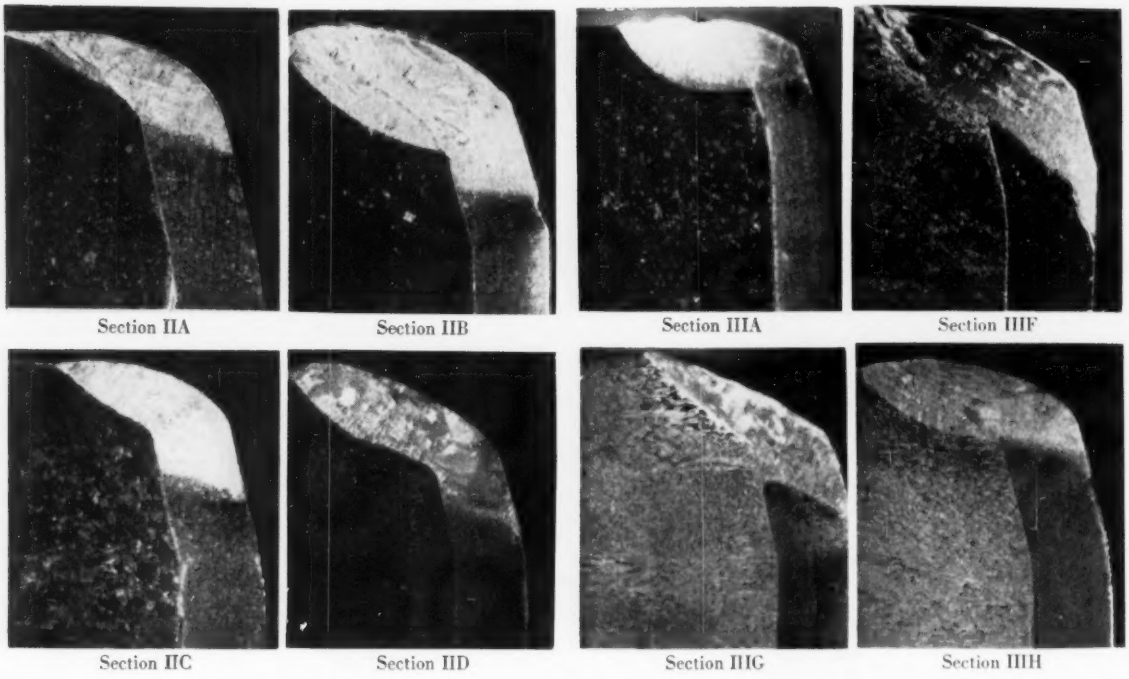
Tube-sheet distortion. Two commercial-size heat-exchanger assemblies are fabricated with copper-silicon tube sheets and admiralty-metal tubes. Each has two tube sheets secured with built-in ends as shown on facing page. A single tube-support sheet is located midway between tube sheets. Securing tube sheets to the frame in this way produces about the same stiffness as a 6-ft-dia tube sheet of the same thickness built-in along its periphery. Flexibility of these tube-sheet strips is about one-third of those used for Sections II and III. Remember that distortion data from Sections II and III is for single tube-sheet units supported at the end only.

Tubes for the first exchanger are installed in skip sequence. (Section IVA), first in one tube sheet and then in the other.

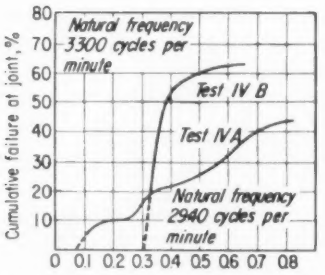
Second-exchanger tubes are installed in consecutive sequence (Section IVB). Each tube is welded in both tube sheets before installing the next tube. Since tubes act as stays, keeping almost a constant distance between tube sheets, skip sequence is an unnecessary refinement.

Table, facing page, summarizes the tube-sheet distortion data taken from Section IV. Each simulated heat exchanger uses 142 tubes. One-half of them, evenly spaced, are rolled in addition to welding. These are samples for cyclic stress test **Turn page**

Automatic welding equipment gives greater weld penetration



2 Photomicrographs of metallurgical sections were taken at 12 diameters and identified by test section. Weld quality and penetration is shown for various material combinations. Joints for study were selected at random, mounted, polished and etched



4 Rate of cyclic stress failure, once failure occurs, is more rapid for Part B

Figure 1 is the tube-sheet distortion profile after each step of tube installation. For both exchangers swaging is done with tube sheets mounted in the test frame and the two ends secured in a built-in support. Tubes are backed up by a bumper bar to hold them in place during swaging of their ends. Each tube is about 8-ft long with a $\frac{5}{8}$-in. rise at the center support sheet. Because of this tube flexibility a high bending load is transmitted to the tube sheets compared to that produced by swaging against the backing plate in Sections II and III. Resulting positive distortion in Section IV is opposite to that observed before.

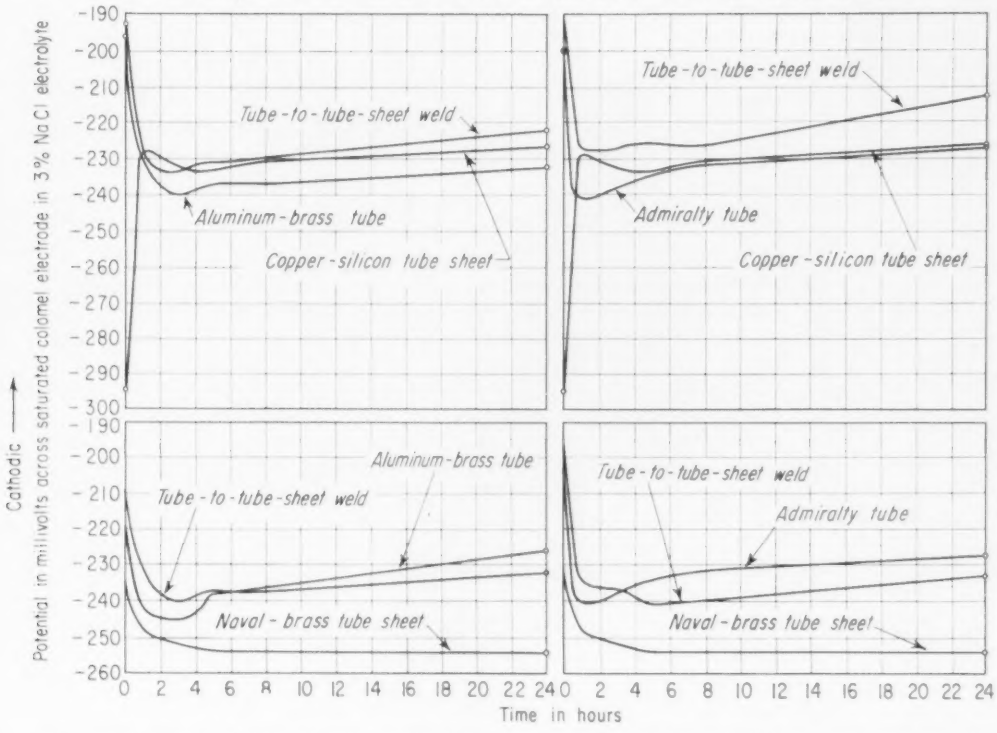
Welding gives relatively little distortion. One test is zero at the reference point of measurement and the remaining three are negative.

Data from Sections II, III and IV is consistent since welding distortion is generally opposite to distortion from swaging. So it looks like any permanent set in the tube sheet from cold working will be reversed or lessened by annealing effect of welding. Our lightly restrained tube

Minor alloying elements in weld admixtures and base metals

Test	Materials		Average amounts of minor alloying elements in %								
	Tube	Tube sheet	Al		As		Sn			Si	
			Tube	Weld	Tube	Weld	Tube	Tube sheet	Weld	Tube sheet	Weld
III A & C	Al-Br	Cu-Si	1.8-2.5	0.94	0.02-0.1	0.02				2.8-3.6	1.38
III B & D	Admiralty	Cu-Si			0.02-0.1	0.03	0.9-1.2			2.8-3.6	0.88
III E & G	Al-Br	Naval brass	1.8-2.5	0.94	0.02-0.1	0.03		0.5-1	0.35		
III F & H	Admiralty	Naval brass			0.02-0.1	0.03	0.9-1.2	0.5-1	0.36		

Maximum potential difference is well within safe limits



3 Electromotive characteristics of these galvanic couples show only one case where potential across weld metal and calomel cell falls between the potentials produced with calomel cell and joint materials. In the three other cases weld metal is more noble

sheets in Sections II and III show high welding distortion. In every case it's higher than that from swaging. But with the more restrained tube sheets in Section IV, distortion from swaging is greater than from welding. In fact weld distortion is so much smaller that it's relatively unimportant.

Part B tube installation gives less welding distortion than Part A. But average total tube-sheet distortion of Part B is greater than Part A. In either case there's little to justify selecting one installation method over the other. It looks as if a compromise method chosen on the basis of convenience is the best bet.

We suggest welding-in enough stay tubes in both tube sheets to increase tube-sheet stiffness and help keep their initial parallel position. As in Part B, install remainder of tubes and weld in consecutive sequence. Complete all welds in one tube sheet first and then weld-in the second tube sheet.

This method follows the principles used for both Parts A and B. You can expect no more tube-sheet distortion from this method than from any of the conventional ways of installing condenser tubes where both ends are rolled and no welding is used. And special tube-to-tube sheet geometries such as trepanning aren't necessary for close control of tube-sheet distortion.

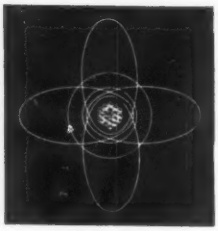
Tube stress. Table, page 108, gives the longitudinal stress in three tubes after welding, peening and rolling. Strain gages indicate tension or compression stresses in a tube on each edge of the tube bank and one at the center. Each reading is an average from four gages and is taken after welding, after peening and after rolling. Accuracy of stresses under 500 psi is questionable since this is less than the strain gage's lower sensitivity range.

Most of the stresses from welding and peening are too low to be accurate. But they demonstrate that both tension and compression exists in the tubes after welding. And they show that peening can reverse direction of stress. Note (*Continued on page* 208)

Electromotive force from galvanic couples in a 3% aqueous solution of NaCl

Galvanic couple	Emf in millivolts (after 24 hours)
Aluminum brass with copper-silicon	5
Weld with copper-silicon tube sheet	5
Weld with aluminum-brass tube	10
Admiralty with copper-silicon	1
Weld with copper-silicon tube sheet	14
Weld with admiralty tube	15
Aluminum brass with naval brass	22
Weld with naval-brass tube sheet	28
Weld with aluminum-brass tube	6
Admiralty with naval brass	27
Weld with naval-brass tube sheet	22
Weld with admiralty tube	5

Note—All samples degreased with CCl_4 and surface film removed with HNO_3 solution



Nuclear notes

By B G A SKROTZKI, Associate Editor

Organic-moderated reactor plant moves nearer reality with the AEC reaching agreement on basis for contract arrangements with parties involved. Atomics International Division would research, develop, fabricate and build 12.5-mwe reactor moderated and cooled by high-boiling-point hydrocarbon and fueled by slightly enriched uranium. City of Piqua, Ohio, would provide site on Great Miami River at its existing steam plant, and the turbine-electric cycle equipment. Piqua would run the entire plant for 5 years as part of its electric and industrial-steam system, buying the reactor steam from the AEC. AEC would spend $12.3 million and Piqua about $4 million. Initial operation would be in July 1961. AEC retains title to the entire reactor plant and fuel elements.

Closed-cycle boiling-water reactor plant also gets moving with the AEC reaching agreement on basis for contract arrangements with builder and operator. The Nuclear Products-Erco Div of ACF Industries, Inc would design, develop, fabricate, build and test operate a closed-cycle boiling-water nuclear reactor and conventional fuel-fired superheater with 22-mwe capacity. Light water would moderate and cool the thorium- and uranium-oxide fueled reactor. The Rural Cooperative Power Association of Elk River, Minn. would provide the turbine-electric cycle equipment at its existing steam plant. RCPA would run the entire plant for 5 years, buying the reactor steam from the AEC. AEC would spend about $11.5 million and RCPA about $1.8 million. Plant would start by October 1960. AEC retains title to entire reactor plant, fuel elements and superheater.

Steps to fusion power involve three goals: (1) bring plasma to "ignition" temperature (2) make a thermonuclear reactor yielding net power (3) make an economic power reactor. At ignition temperature, energy output of nuclear reactions at least equals the energy radiated by the plasma to surroundings. AEC scientists think they can do this within a few years. So far no real proof has been found that a reactor can produce a net power output; in any event a power producer is many years in the future, so don't sell uranium short.

Industrial heating reactors will be designed and built by Georgia Nuclear Laboratories of the Lockheed Aircraft Corp. GNL with space at Lockheed's Marietta, Ga., plant will also design and make research reactors and small atomic power plants. GNL claims its preliminary studies show it can produce competitive industrial heat from nuclear reactors.

Sodium graphite reactor plant of the Consumers Public Power District of Nebraska nears the hardware stage as the AEC appoints Bechtel Corporation as architect-engineer. The 75-mwe plant will take about 3½ years to build. Atomics International Division has technical responsibility for the reactor equipment.

Nuclear Ship Savannah had its keel laid on May 22 at the New York Shipbuilding Corp's yards at Camden, N. J. Shp of 20,000 will be developed by pressurized-water reactor to be built by Babcock & Wilcox Co (POWER, January 1958, p 96). AEC is negotiating a contract with Gereral Electric Co for developing and possibly fabricating the second core for the reactor.

Engineering test reactor, nation's largest, at Idaho Falls, Idaho, began running at its design level of 175 mwt on April 19, gives highest neutron flux.

Perforated for your filing ease

Power's data sheet

No. 310

Alloy-steel pipe to ASTM Spec A-335 Grade P-12 (1 Cr½ Mo)

Pipe Size In.	Nom. OD In.	Wall Thick In.	Temperature — F: To 800	850	900	950	1000	1050
			Maximum Allowable Stress — PSI: 15,000	14,400	13,100	11,000	7800	5500
Schedule 10								
14	14	.250	330	317	288	245	174	123
16	16	.250	291	279	254	214	152	107
18	18	.250	255	245	222	190	135	95
20	20	.250	233	223	203	171	121	86
24	24	.250	195	187	170	143	101	71
Schedule 20								
8	8.625	.250	540	518	471	400	285	201
10	10.75	.250	435	418	380	319	228	161
12	12.75	.250	366	351	320	269	192	135
14	14	.312	450	432	393	332	237	167
16	16	.312	390	374	341	290	207	146
18	18	.312	345	331	301	257	183	129
20	20	.375	399	383	353	293	210	148
24	24	.375	330	317	288	244	174	121
Schedule 30								
8	8.625	.277	630	605	550	462	329	231
10	10.75	.307	578	554	504	425	304	214
12	12.75	.330	534	518	471	393	281	198
14	14	.375	570	547	498	421	301	212
16	16	.375	495	475	432	368	262	185
18	18	.438	540	518	471	394	281	198
20	20	.500	570	547	498	418	299	211
24	24	.562	540	518	471	399	285	201
Schedule 40								
½	.84	.109	1695	1627	1480	1256	911	643
¾	1.05	.113	1455	1397	1271	1074	777	548
1	1.315	.133	1569	1506	1375	1163	842	594
1¼	1.66	.14	1059	1022	930	781	563	397
1½	1.90	.145	1005	965	877	742	533	376
2	2.375	.154	906	870	786	668	480	338
2½	2.875	.203	1215	1166	1061	899	648	457
3	3.50	.216	1095	1051	956	808	581	410
4	4.50	.237	975	936	851	717	515	363
5	5.563	.258	885	850	773	656	471	332
6	6.625	.28	833	799	727	614	440	310
8	8.625	.322	771	740	668	568	407	287
10	10.75	.365	720	691	628	533	381	269
12	12.75	.406	690	662	603	512	366	258
14	14	.438	690	662	603	509	365	257
16	16	.50	713	684	622	525	376	265
18	18	.562	726	697	634	535	383	270
20	20	.593	690	662	603	511	365	258
24	24	.687	683	655	596	503	360	254
Schedule 60								
8	8.625	.406	1035	994	904	765	550	388
10	10.75	.50	1071	1028	930	791	569	401
12	12.75	.562	1035	994	904	762	548	386
14	14	.593	999	959	872	737	530	374
16	16	.656	975	936	851	723	520	366
18	18	.750	1011	971	883	746	537	378
20	20	.812	990	950	864	733	527	371
24	24	.968	1005	965	877	774	557	393
Schedule 80								
½	.84	.147	3036	2915	2646	2272	1681	1185
¾	1.05	.154	2589	2485	2266	1932	1420	1001
1	1.315	.179	2612	2507	2281	1949	1433	1010
1¼	1.66	.191	1935	1857	1690	1441	1049	740
1½	1.90	.20	1821	1748	1585	1352	983	693
2	2.375	.218	1665	1598	1454	1232	894	630
2½	2.875	.276	1943	1865	1696	1443	1051	741
3	3.50	.30	1770	1699	1545	1312	953	672
4	4.50	.337	1599	1540	1401	1185	859	606
5	5.563	.375	1470	1411	1283	1092	790	557
6	6.625	.432	1470	1411	1283	1091	789	556
8	8.625	.50	1344	1290	1174	995	718	506
10	10.75	.593	1311	1259	1145	970	700	494
12	12.75	.687	1305	1252	1140	965	597	491
14	14	.75	1311	1259	1140	970	700	494
16	16	.843	1305	1252	1140	967	698	492
18	18	.937	1305	1252	1140	963	695	490
20	20	1.031	1299	1252	1134	961	693	489
24	24	1.218	1290	1238	1127	958	691	487

Pipe Size In.	Nom. OD In.	Wall Thick In.	Temperature — F: To 800	850	900	950	1000	1050
			Maximum Allowable Stress — PSI: 15,000	14,400	13,100	11,000	7800	5500
Schedule 100								
8	8.625	.593	1650	1584	1441	1222	886	625
10	10.75	.718	1635	1569	1428	1216	881	622
12	12.75	.843	1650	1584	1441	1226	889	627
14	14	.937	1695	1627	1480	1254	910	642
16	16	1.031	1635	1569	1428	1214	881	621
18	18	1.156	1650	1584	1441	1221	886	624
20	20	1.281	1650	1584	1441	1227	890	627
24	24	1.531	1665	1598	1454	1235	896	632
XX								
½	.84	.294	9222	8853	8054	7206	5880	4146
¾	1.05	.308	7532	7231	6578	5815	4611	3251
1	1.315	.358	7140	6854	6236	5498	4331	3054
1¼	1.66	.382	5580	5357	4873	4250	3266	2303
1½	1.90	.400	5115	4910	4467	3883	2963	2089
2	2.375	.436	4485	4306	3917	3390	2562	1807
2½	2.875	.552	4935	4738	4310	3742	2847	2006
3	3.50	.600	4410	4234	3851	3332	2515	1773
4	4.50	.674	3855	3701	3367	2902	2172	1532
5	5.563	.750	3480	3341	3039	2613	1945	1371
6	6.625	.864	3420	3283	2987	2566	1909	1346
8	8.625	.875	2609	2504	2278	1947	1431	1009
Schedule 120								
4	4.50	.438	2235	2145	1951	1667	1219	860
5	5.563	.50	2130	2045	1860	1581	1154	814
6	6.625	.562	2040	1958	1781	1515	1105	779
8	8.625	.718	2070	1987	1808	1536	1120	790
10	10.75	.843	1980	1900	1729	1469	1070	755
12	12.75	1.00	2010	1930	1755	1493	1088	767
14	14	1.093	2010	1930	1755	1495	1090	768
16	16	1.218	1980	1900	1729	1468	1069	754
18	18	1.375	1995	1915	1742	1485	1082	763
20	20	1.50	1965	1886	1716	1462	1065	751
24	24	1.812	2003	1922	1749	1488	1085	765
Schedule 140								
8	8.625	.812	2385	2290	2082	1778	1303	919
10	10.75	1.00	2406	2310	2101	1793	1314	927
12	12.75	1.125	2295	2203	2004	1709	1251	882
14	14	1.25	2340	2246	2043	1745	1278	901
16	16	1.438	2376	2281	2070	1770	1297	915
18	18	1.562	2304	2212	2017	1716	1256	886
20	20	1.75	2340	2246	2043	1740	1274	898
24	24	2.062	2310	2218	2017	1718	1258	887
Schedule 160								
½	.84	.187	4545	4363	3969	3441	2603	1835
¾	1.05	.218	4500	4320	3930	3404	2573	1815
1	1.315	.25	4296	4124	3752	3243	2444	1723
1¼	1.66	.25	3006	2886	2620	2249	1663	1173
1½	1.90	.281	3090	2971	2698	2317	1715	1210
2	2.375	.343	3225	3096	2816	2417	1793	1264
2½	2.875	.375	2961	2843	2586	2215	1637	1154
3	3.50	.438	2930	2812	2558	2191	1618	1141
4	4.50	.531	2871	2756	2502	2146	1584	1117
5	5.563	.615	2790	2679	2436	2087	1538	1085
6	6.625	.718	2730	2621	2384	2043	1504	1061
8	8.625	.906	2715	2605	2371	2028	1493	1053
10	10.75	1.125	2753	2642	2404	2056	1515	1068
12	12.75	1.312	2730	2621	2384	2043	1504	1061
14	14	1.406	2670	2563	2332	1997	1469	1036
16	16	1.593	2670	2563	2332	1992	1466	1034
18	18	1.781	2670	2563	2332	1990	1464	1032
20	20	1.968	2663	2556	2325	1988	1462	1031
24	24	2.343	2655	2550	2318	1983	1459	1029

Maximum allowable working pressures—5

Figures in table give maximum psi pressure for given temperatures and stresses. See February *Data Sheet* 306 for basic formula from which table was calculated.

GEORGE C HALZELL, *Boston, Mass.*

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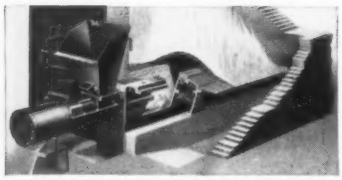
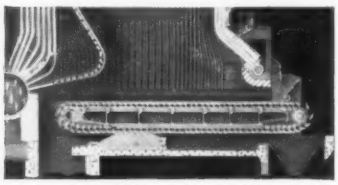
For years past . . . and years to come . . .

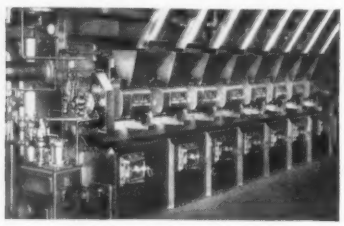
FIRST IN FUEL BURNING EQUIPMENT WITH THE MOST COMPLETE LINE OF THE INDUSTRY



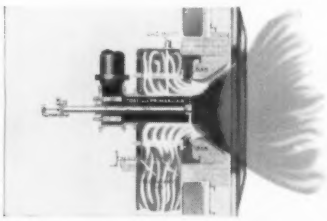
Riley Side Dump Stokers with stationary or moving combustion grates.



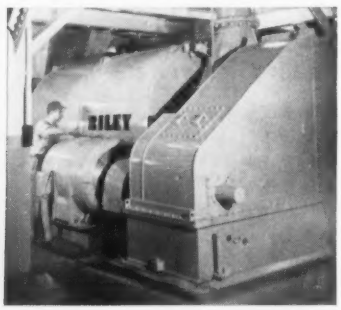
Riley Traveling Grate Stokers for burning low grade coals, anthracite and coke.



Riley Spreader Stokers for steam capacities up to 350,000 lbs./hr.



Riley Flare Type Burners for pulverized coal, oil and gas.



Riley Ball Tube Mills for low grade, high abrasive coals.

RILEY'S COMPLETE LINE OF FUEL BURNING PRODUCTS WILL ENABLE YOU TO SOLVE ANY CONCEIVABLE FUEL BURNING PROBLEM

ANTHRACITE
- Riley-Harrington Traveling Grate Stoker
- Riley RT Traveling Grate Stoker

BITUMINOUS
- Riley Stoker (Multiple Retort)
- Riley Dumping Grate Spreader Stoker
- Riley Traveling Grate Spreader Stoker
- Riley Oscillating Grate Spreader Stoker
- Riley Side Dump Underfeed Stoker
- Riley-Harrington Traveling Grate Stoker
- Riley RT Traveling Grate Stoker
- Riley Pulverizers
- Riley Ball Mills
- Riley Flare Type Burners
- Riley Turbo Furnace

PETROLEUM COKES
- Riley-Harrington Traveling Grate
- Riley RT Traveling Grate Stoker
- Riley Pulverizers
- Riley Flare Type Burner
- Riley Turbo Furnace

RILEY FUEL BURNING AUXILIARIES
- Riley Automatically Controlled Ignition System
- Riley Continuous Spark Ignitor
- Riley Fuel Proportioner (Unhogged Bark)
- Riley Chain Type Feeder (Bagasse, Cellulose Fuels)
- Riley Worm Type Feeder
- Riley Stop Valves
- Riley Crusher Dryer } Pulverizers
- Riley Feeder Crushers } Ball Mills

SEMI-ANTHRACITE
- Riley Dumping Grate Spreader Stoker
- Riley-Harrington Traveling Grate Stoker
- Riley RT Taveling Grate Stoker

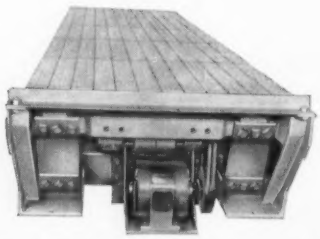
LIGNITE
- Riley Dumping Grate Spreader Stoker
- Riley Traveling Grate Spreader Stoker
- Riley-Harrington Traveling Grate Stoker
- Riley RT Traveling Grate Stoker
- Riley Pulverizers
- Riley Flare Type Burners
- Riley Turbo Furnace

FLUID COKE
- Riley Pulverizers
- Riley Turbo Furnace

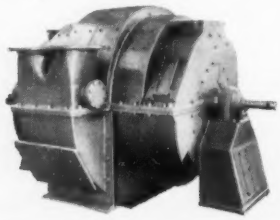
OIL, GAS (Natural, Blast Furnace, Coke Oven)
- Riley Flare Type Burners
- Riley Intertube Burners
- Riley Turbo Furnace

REFUSE FUELS
- (Waste Woods — Hogged Bark, Unhogged Bark, Bagasse)
- Pneumatic Spreader Stoker with either Dumping Grate, Traveling Grate, Water Cooled Grate, or Oscillating Grate

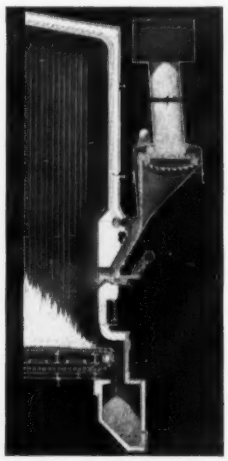
(Other Refuse Fuels: Wood Bark, Bagasse, Queechee Nuts, Grape Offal, Sunflower Seeds, Cotton Seeds, Eucalyptus Wood, Sawdust, etc.)



Riley Oscillating Grate, both spreader and hopper fired.



Riley "50" Pulverizers in capacities from 5000 to 50,000 lbs./hr. of coal per hr.



Riley Pneumatic Spreader Stokers for burning fuels such as wood, bark, bagasse.

A survey of your power plant by a consulting engineer will possibly show ways of making surprisingly large savings in your power costs.

Sales Offices: Worcester, New York, Philadelphia, Buffalo, Pittsburgh, Cleveland, Detroit, Chicago, Cincinnati, Charlotte, New Orleans, Atlanta, St. Louis, Kansas City, St. Paul, Houston, Denver (Englewood), Salt Lake City, Los Angeles, San Francisco, Portland, Seattle.

LEY

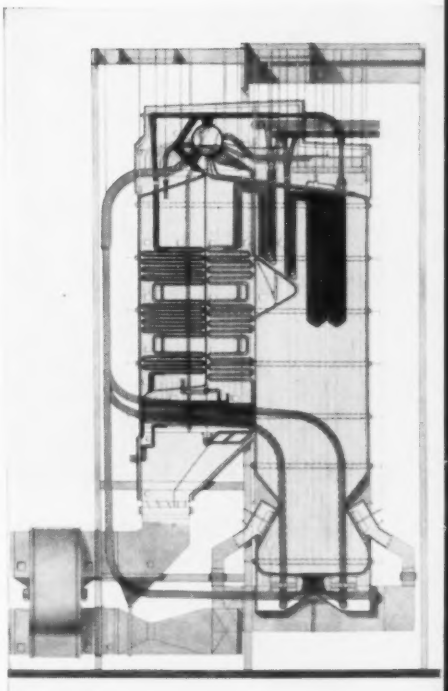
Today and Tomorrow...

A LEADER IN THE DESIGN, MANUFACTURE AND ERECTION OF PUBLIC UTILITY AND INDUSTRIAL STEAM GENERATING EQUIPMENT

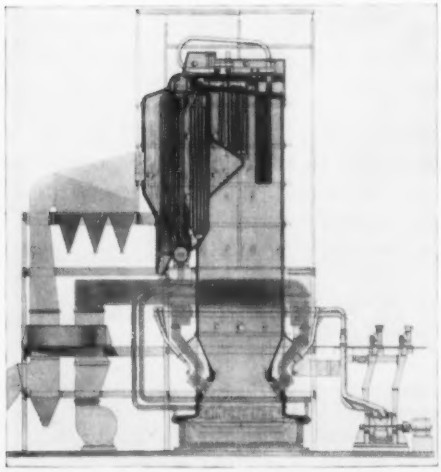
RILEY STEAM GENERATING UNITS HAVE PRODUCED AN OUTSTANDING RECORD FOR DEPENDABILITY AND EFFICIENCY

Over the years Riley Boilers have produced an outstanding record of performance for their users. This record has in turn supplied Riley a large reserve of satisfied customers who consistently install Riley boilers as their production facilities expand. Today, Riley is considered one of the foremost suppliers of steam generating equipment in the world. Riley boiler designs cover every steam capacity and pressure required for modern industrial power plants and public utility installations. A complete Riley Steam Generating Unit includes boiler, superheater, reheater, economizer, air heater, waterwalls and steel clad or pressurized setting. With fuel burning equipment selected from Riley's wide range of fuel burning products users are able to purchase complete steam generating units fabricated, erected and serviced under a single contract without divided responsibility. Whatever your steam and fuel burning requirements may be, you can rely on Riley to provide a highly efficient unit that will assure satisfactory and dependable service for many years.

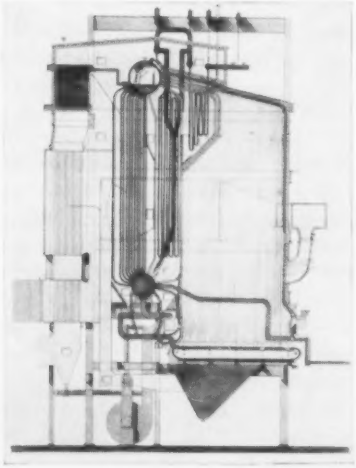
RILEY STOKER CORPORATION
WORCESTER, MASSACHUSETTS



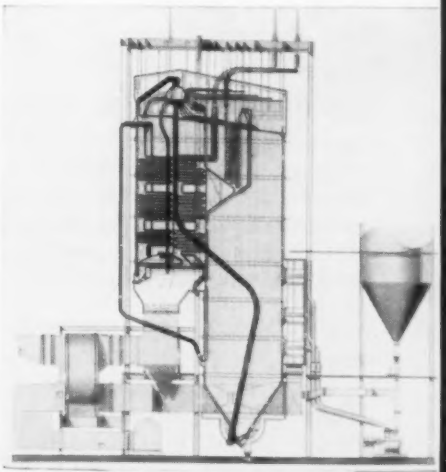
This Riley 1,000,000#/hr. **TURBO FURNACE** Pressurized Reheat Boiler is being installed by Louisiana Power & Light Co. to burn gas initially oil, coal, fluid coke or lignite in the future. 2125 psig; 1005/1005F.



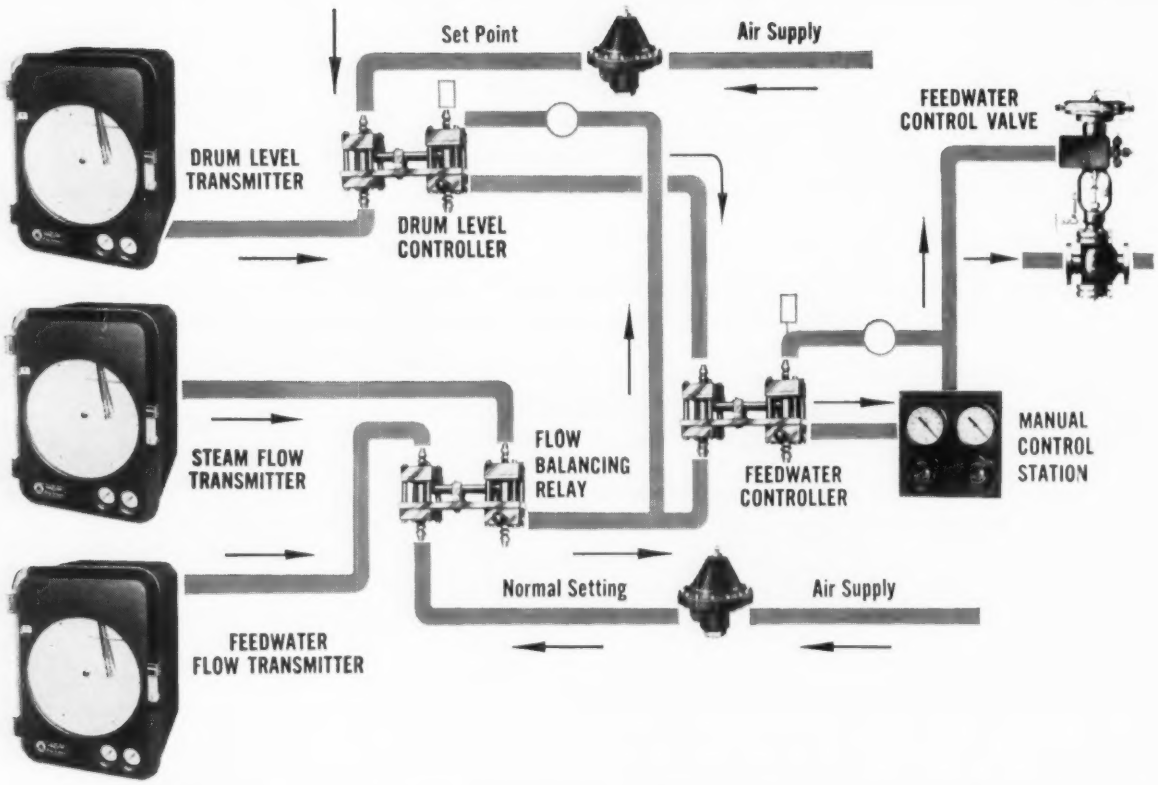
This 500,000 lb./hr. **TURBO FURNACE** Unit was designed specifically to burn FLUID COKE.



A lignite burning **Riley Boiler;** Spreader Stoker firing. Also gas and oil fired thru Riley **Intertube Gas/Oil Burners.**



A Riley Reheat Unit that features the exclusive cost saving **Riley Single Header Hopper Bottom.**



Hagan 3-Element Feedwater Control features compensated measurements and Automatic Level Monitor

Modern boiler design demands a higher degree of accuracy and response in feedwater control. The Hagan 3-element system meets this demand by providing exceptional precision of measurement and flexibility in interpreting measurement into action. Here are some reasons why the Hagan system is outstanding:

COMPENSATION—The three major measurements—drum level, feedwater flow and steam flow—can be made with Hagan Ring Balance meters compensated for variations in fluid density. This permits maintenance of accurate automatic control over a wider range of operating conditions, especially at start-up and shut-down.

WIDE-RANGE ADJUSTMENT—The use of wide-range Hagan Ratio Totalizers as flow-balancing relays and controllers allows independent adjustment of the influence of each variable. This provides flexibility and accuracy in matching the control system to boiler and load characteristics.

AUTOMATIC LEVEL MONITOR—holds drum level at the set point by compensating for discrepancies between steam generated and steam measured. In ordinary 3-element systems the level is depressed or elevated by such discrepancies as, for instance, during blowdown or steam soot-blowing when steam is being used which is not measured by the steam flow meter.

LEVEL INFLUENCE FROM BOILER LOAD—can be incorporated to hold level above normal at high loads and below normal at low loads. Write for Bulletin MSL-3, which describes such an installation on a 400 Mw station.

HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

Plant maintenance and management section

STEVE ELONKA
Associate Editor in Charge

Higher temperatures and hydrocarbons won't hurt . . .

Viton: your new design material

Now, along comes DuPont's new synthetic rubber for service in oils, fuels and solvents at over 400 F. It's a linear copolymer of vinylidene fluorine by weight. A number of uses have proven this new elastomer; largest to date is aircraft seals. Other uses are for hoses, protective clothing, fuel cells, wire insulations, calking, paint, etc.

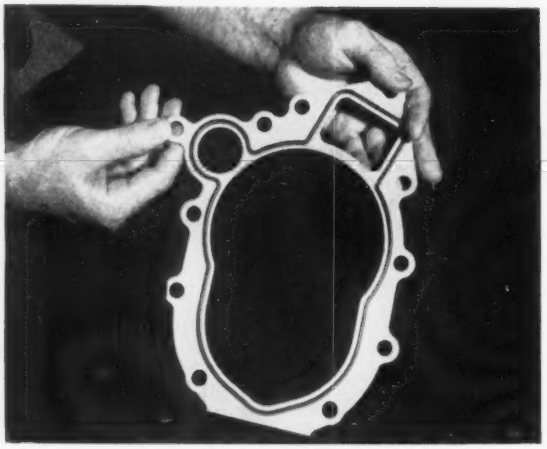
Because today's temperatures are skyrocketing in many types of power equipment, this material is being considered for pumps, instruments and most anything that needs seals.

Example of toughness is its use as a valve-stem seal on heavy-duty gasoline engines. Engines use sodium-cooled exhaust valves, causing very high temperatures at valve-stem seal. Seals of conventional oil-resistant elastomers rapidly become brittle and fail. But seals made of this new synthetic rubber remain elastic and maintain a tight fit around the valve stem after many thousands of miles.

Other uses are for brake cups, pump seals, gasoline pumps, thermostat bellows, firewalls, fuel tanks, portable storage tanks, etc. Elastomers hold an important spot among design materials; they provide for flexibility in mechanical systems.

Turn page

Courtesy of:
E I duPont de Nemours & Co, Inc
Elastomer Chemicals Department



GASKET, made of Viton, is molded in place

Here are some punishments this rubber will take and some jobs you can give it in your plant

Properties

Most valuable properties of Viton are (1) good performance at temperatures of 400 F and up (2) resistance to most of the exotic new lubricants, fuels and hydraulic fluids of the jet age (3) mechanical properties that are respectable for any elastomer and excellent for one that is super-resistant to heat and fluids.

No commercial elastomer equals this new synthetic rubber in resistance to oils, fuels and solvents at temperatures over 400 F. There are some plastics suitable for these temperatures, but they lack physical properties of Viton, notably its resistance to compression set.

Resistance to heat aging. When Viton is exposed to dry heat and tested to failure, the cause of failure is embrittlement. Tensile strength is largely unaffected. When oven aged in air, its vulcanizates remain elastic for more than 2400 hours at 400 F, 1000 hours at 450 F, 250 hours at 500 F, 72 hours at 550 F and 24 hours at 600 F.

Useful life of this order is outstanding among elastomers. This is especially so because this new rubber is also highly resistant to functional fluids.

Resistance to fluids and chemicals. Vulcanizates of Viton are resistant to almost all of the new fuels, lubricants and hydraulic fluids currently of interest in the aircraft and missile industries. Its performance in contact with these fluids at temperatures of 400 F and up is unequalled by any other of today's commercially available elastomers.

Hardness, tensile strength, elongation. Vulcanizates of this synthetic rubber can be made in any hardness from 60 to 95 durometer.

Tensile strength at room temperature is in the range of 2000 to 3000 psi, and ultimate elongation varies from 100 to 400%, depending on hardness. These values are quite respectable for any elastomer and very good for one with exceptional resistance to heat and fluids.

With test specimens heated to and tested at 300 F, tensiles run 300 to 1000 psi and elongations 80 to 200%. Thus, like all elastomers, it loses tensile strength and elongation at elevated temperatures, but the data also tell us it can be compounded to have hot tensile and elongation equal to any elastomer and better than most.

Compression set. Even at high temperatures, stocks of this new rubber have good resistance to compression set, which is often more valuable in mechanical goods than tensile strength. Specimens compressed 25% held 70 hours at 250 F, recovered to within 90 to 97% of their original dimension. This is an excellent performance for gasket material.

Low-temperature properties are not outstanding, but adequate. Typical compounds have Young's modulus of 10,000 psi at –20 F and a brittle point of –47 F. But brittle point is affected by specimen thickness. A –47-F value is obtained on 0.075-in. thick specimen. A 0.025-in. thick specimen has brittle point of –60 F; a 0.010-in. wire coating does not crack at –90 F when bent around mandrel 10 times the wire diameter.

The T10 value is –70 F. This is temperature at which a previously stretched and frozen specimen retracts 10%; it's also the minimum temperature at which rubber-like properties are evident.

Resistance to ozone, weathering. Compositions of this new rubber are highly resistant to deterioration by ozone and weather. Test strips under 25% were exposed to 100 ppm of ozone and showed no sign of cracking after 28 days, when the test was discontinued. Stretched samples have been exposed to direct sunlight in Florida for 12 months and as yet show no sign of cracking. But lower cost of other sun- and ozone-resistant elastomers, notably Hypalon, precludes use of Viton if this is the only property needed.

Electrical properties. Typical stocks will have dc resistivity of 2.5×10^{13} ohm-cm, specific inductive capac-

ity of 16.7, power factor of 4.5% and dielectric strength of 412 volts per mil. These values restrict Viton to low-voltage low-frequency applications. One example is the use of Viton as insulation for hookup wire that is exposed to dry heat and hot oil.

Applications

Seals. An important application of Viton is as a seal because of its resistance to heat, fluids and compression set. It is also used for protective clothing, fuel cells, wire insulation, calking and paint, instruments, transmissions, brakes and other industrial equipment where temperatures are climbing.

Valve-stem seals on truck engines. Air within the valve cover is 325 to 350 F; the temperature of rubber seal where it rubs the valve stem is still higher. Since valve train is lubricated by oil spray, the seal is bathed in oil. Seals of conventional oil-resistant elastomers stand oil, but heat causes them to harden. Viton is expected to remain elastic indefinitely.

Brake cups. Trend toward smaller and more compact brakes results in hotter brake. It places the hydraulic cylinder closer to the friction surfaces where heat is produced. Temperatures at the rubber brake cup have not yet gone beyond limit of conventional elastomers, but they are on the rise and it may not be long before Viton is required to stand the combination of heat and brake fluid.

Front pump seals. Designers of automatic transmissions are under pressure to cut down on size. They can accomplish this, but with the result that the transmission runs hotter. This makes it hotter for seals and gaskets contacting transmission fluid. Hardest hit are the front pump seals—a natural spot for Viton.

Gasoline pumps. New third-pump gasolines have created problems for makers of metering pumps and nozzles. Nozzles and pumps contain some close-tolerance rubber parts which come in contact with fuel that is better than 50% aromatic. Almost no swell is permissible in these parts. This new rubber steps in to fit this need.

Thermostat bellows. New thermostatic controls have thermal expansion and contraction fluid for sensing mechanism. Rubber bellows form part of the enclosure that contains the fluid. Viton will stand this fluid at the higher temperature called for by the controller.

Firewall. In single-engine aircraft, a rubbed-impregnated fire-resistant fabric separates engine compartment from pilot space. Because of increasing engine temperatures, this new rubber is used as the impregnant. It does not support combustion; it will burn if held in a flame but goes out when flame is removed.

Fuel tanks. Fuel cell in aircraft is a bladder made of rubberized fabric. Bladders can be made to fit odd-shaped spaces in the wing and can be pulled out easily and replaced if damaged. Today, some firms use the wing itself as a tank by sealing all the seams and rivet holes. Viton can be used to impregnate and coat the fabric of the bladder type tanks for calking and liquid coating. It can seal the integral type tank. This rubber will stand immersion in aircraft fuel, but real advantage here is against skin temperature of high-speed aircraft. At altitudes over 35,000 ft, skin temperature reaches 200 F at Mach 3. Conventional fuel-resistant elastomers are good up to 250 to 275 F.

Aircraft tires. Because of high skin temperatures, wheel wells of jets get so hot that heat deterioration of tires is a serious problem. Unless wheel wells are air conditioned, tires may have to be made of an air-conditioned elastomer that can stand this heat.

Portable storage tanks. Portable sausage-shaped fuel tanks, say 40 ft long and 6 ft diameter, made of rubberized fabric are practical. They can be rolled up and carried by truck or plane to out-of-way locations.

Commercial status

Availability. Viton was produced in a small pilot plant in 1957. There wasn't enough to meet even the development needs of the rubber industry. So full-fledged commercial usage was out of the question. But a new plant went on the line this year—solving the problem.

Cost. This raw polymer is expensive, selling for $15 a pound. This is 40 times cost of conventional elastomers. But, in any given finished product, a change from conventional elastomer to Viton will not multiply the product's cost by 40. Raw polymer is only part of the cost of a rubber product.

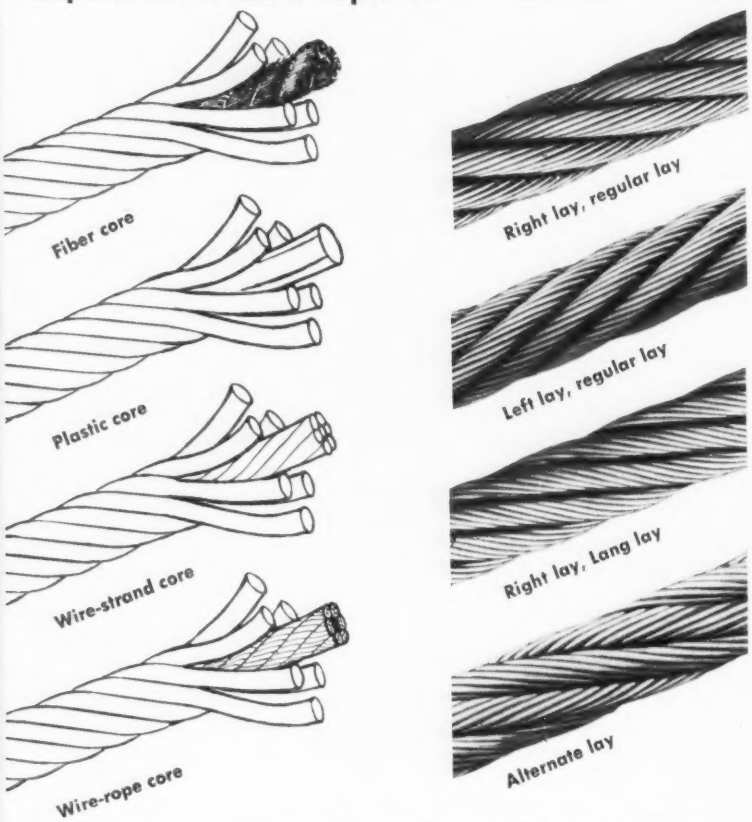
The costs of labor and rejects can be high in the case of precision products. And, there are costs of nonrubber components of the product, like wire braid in hose and springs in shaft seals. In some products, these nonpolymer costs are a large percentage of total costs. So a change from conventional elastomer to this synthetic rubber may not even double the total cost.

Other products, like a big die-cut gasket, are almost all rubber; nonpolymer costs are relatively low and Viton could multiply total cost by a much larger factor—but not by a factor of 40.

Designers who need a rubber to stand heat and fluids should not let price scare them away from this new rubber too quickly. Real quotations on the finished product may not be so bad after all.

Sources. DuPont's Elastomer Chemicals Department makes the raw polymer of Viton, but no finished products. They sell polymer to rubber manufacturers, who process and fabricate finished products on same equipment and by same methods they use with conventional elastomers. Your present supplier is your source for products made of Viton. For additional information on this subject, write to E I duPont de Nemours and Co, Inc, Elastomer Chemicals Department, Wilmington 98, Delaware.

Rope construction is important . . . and so is the lay



CRUSHED into the sheave by overloading, rope's worn strands leave imprint in metal. This means replacement of rope and sheave

It pays to know the ropes

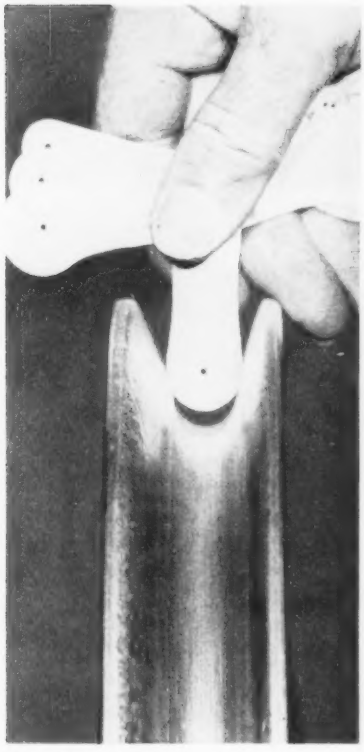
Matching the right wire rope to the job and giving rope topnotch care in use and in storage will get you better service and more of it for the same money

By G I PINE, Plant Manager
Leschen Wire Rope Div, H K Porter Co, Inc

Wire rope is probably one of the most unsung heroes of our day. Its steel sinews back up much of the mechanical muscle that lifts or hauls heavy burdens in our central stations and industrial plants. Fortunately, it's built to take abuse. But abuse, though unavoidable at times, tends to shorten wire-rope's life, just as it affects other machines. For wire rope is a machine; it has moving parts that must be kept working smoothly if it's to give top efficiency.

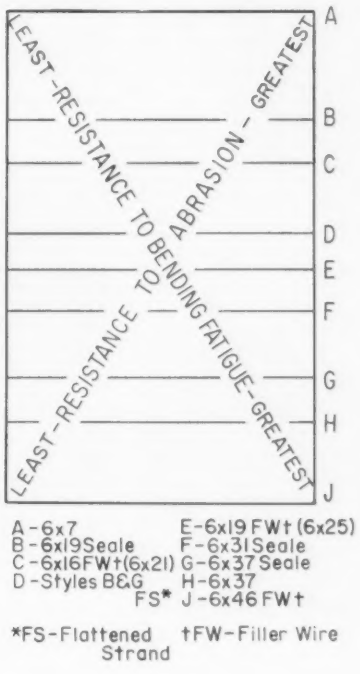
On the surface, all wire rope looks somewhat alike. But a close look shows almost a hundred different types, each having its own physical makeup and varying degrees of suitability for any given job. It isn't necessary to know all the fine details to get top performance from your rope. So let's talk about the most important factors—the ones that can make a real difference in your wire-rope costs.

It's important to know something about wire-rope parts, see drawings, above. The core is the rope's foundation. It keeps the rope round and keeps its strands correctly spaced and supported. Fiber, steel strand, wire rope and plastic are four common cores. The fiber core is a carefully sized, prelubricated, hard-laid sisal or manila rope especially selected for toughness and compression resistance. It's used for practically any application except those involving high temperature, corrosion or serious crushing action. Wire-strand and wire-rope cores are just what their names imply. They're used for higher temperatures and have higher resistance to crushing. Plastic cores, relatively new, combine certain advantages of fiber cores with increased



WORN ROPE cuts own deep channel in sheave. New rope won't fit, will damage sheave further and quickly ruin the rope

X-chart simplifies rope-construction choice



Resistance to abrasion and bending fatigue are the two factors which govern most decisions in selecting wire rope. As a rule, too, they require the most judgment.

Chart shows how the most-used rope constructions compare with each other in fatigue and bending resistance. Safest course is to stay as close as possible to chart's center to get even balance. Up or down along X's legs gives gain on one quality and loss on the other.

Remember, you can't have everything. Rarely, if ever, will you realize the wire-rope engineer's dream—an absolute match of job to equipment to rope. What you're usually after is the most efficient and economical of all available compromises for your own job.

resistance to corrosive liquids and gases.

Rope "lay" is important to the user, too. Drawing, facing page, shows the most commonly used types. Rope may be either right or left lay. As you look at the end of a *right-lay* rope, its strands spiral away from you clockwise (*left-lay* strands spiral away from you counterclockwise).

Right-lay ropes are considered standard and are used for most services. But, natural tendency of a wire rope to twist or "unwind" often makes a left-lay rope a must. In addition to lay direction, there are types of lay—regular, Lang or alternate. Each type has its advantages and disadvantages. Example: Lang lay is more flexible and more resistant to abrasion than regular lay. But Lang is harder to handle, more susceptible to crushing and should never be used with swivels or free ends. Alternate lay is a combination of regular and Lang. It's normally used to prevent rotation.

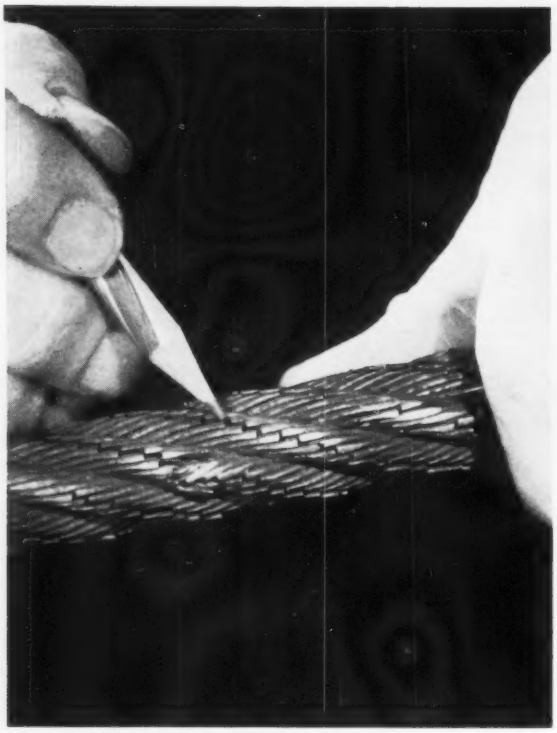
Key to knowing what rope is best for the job is in correct appraisal of its reserve strength and its resistance to (1) breaking (2) bending fatigue (3) abrasion and (4) crushing.

How strong must a wire rope be to operate safely? First, determine the heaviest load it will have to lift or haul. Next, will it be subjected to sudden shock loads, high-speed operation, etc? These conditions can, in effect, increase a load by several times its actual weight.

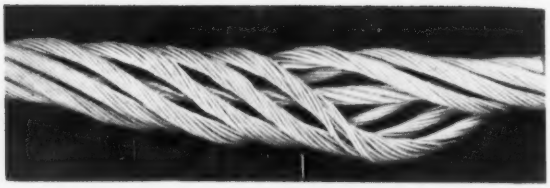
A 5:1 safety factor generally determines a rope's working load. This means that the working load won't exceed one-fifth rope's breaking strength. The factor varies, depending on rope's length and diameter, number and arrangement of sheaves, size of drum and fittings, hazard to human life.

Bending fatigue (work hardening) constantly works to destroy wire rope operating around sheaves or drums. Proportion between diameters of ropes and sheaves or drums has an important bearing on how soon fatigue will weaken a rope to the danger point. This proportion can be expressed conveniently in the formula D/d, in which D is sheave or drum diameter and d is rope diameter. Another convenient ratio divides sheave or drum diameter by diameter of one of the outside wires. A slight error in calipering a wire can throw results far out of line, so be careful in using this method. In applying either of the two ratios, bear in mind that the higher the operating speed and heavier the load, the larger the D/d ratio must be to insure maximum resistance to bending fatigue.

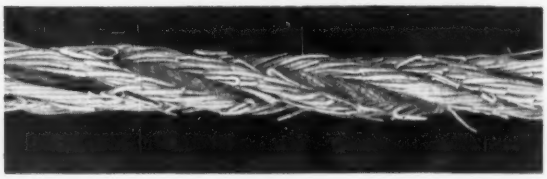
Theoretically, the higher the D/d ratio, the greater the rope's immunity to fatigue damage. However, both weight and momentum build up rapidly as sheaves grow larger. A heavy sheave tends to keep on spinning after the rope stops, causing severe abrasion at that point. Too, when the rope starts again, there's considerable slippage and wear before friction between rope and sheave overcomes the latter's inertia. But in most cases where practical limits of size and



PARTED WIRES are due to excessive bending fatigue resulting from operation with too-small sheaves for rope's size and type



BIRDCAGING can result from sudden release of an overstressed rope. Still intact, wire-rope core illustrates extent of damage



LUBRICATION would have prevented the corrosion that destroyed this rope. Two strands were removed to show internal condition

ANOTHER CASE for good lubrication. Broken outside wires show little wear or corrosion, but pitted interior tells the story

Good handling, lubrication, inspection add life to your rope

weight aren't exceeded, using correct D/d ratio will pay off handsomely in longer service life for your wire rope.

Abrasion may be the culprit though suspicion points to fatigue because of broken wires. If the broken wires are worn badly it's usually safe to assume that abrasion weakened them to the breaking point. In wire rope, abrasion wears metal from crowns of outside wires. It's indicated by small flat spots which grow at a rapid rate when the rope is new. If wear rate seems excessive, you may be able to check it by shifting to a harder steel rope. But be sure you're not getting increased abrasion resistance while sacrificing flexibility or other qualities demanded by the job.

Crushing is a real wire-rope destroyer. The rope doesn't have to be smashed pancake-flat to be weakened; normally harmless bending stresses can break wires at the crushed point. Pinching rope in a too-narrow sheave groove will crush it, possibly not enough to be noticeable, but the damage is done. A crushed rope can't function normally because the wires can't move smoothly against each other over a bend.

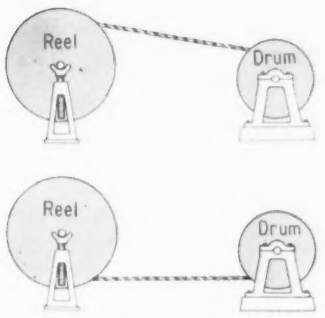
Overloading is the chief rope-crusher. Photo, p 120, shows how overloading can pull a rope so tightly onto a sheave that its imprint is literally crushed into the sheave. Neither rope nor sheave last long under such operating conditions. Slap-dash operation with abrupt starts and stops adds to the crushing toll, too. Banging hard against a sheave or drum will flatten wire rope in a hurry. Jerk-free operation can save many a dollar.

Excessive wear will develop if a rope runs over a sheave with a too-large or too-small groove diameter. The rope will cut its own wider channel if the groove is too narrow, photo, p 121. If the groove is too wide, the rope doesn't get proper support. It will work from side to side, wearing both rope and sheave. To give good support, sheave groove should take in about 150 deg of the rope's circumference, though this may have to be reduced to about 130 deg if a large fleet angle can't be avoided.

Fleet angle is the included angle between a line representing rope's greatest travel across a drum and a line drawn through center line of the head or guide sheave at right angles to the drum axis. Fleet angle shouldn't exceed 1½ deg for a smooth drum or 2 deg for a grooved drum. If feed sheave is too close to the drum the angles will be exceeded. This makes the rope scrub against the preceding wrap and it tends to climb on itself near the end of its travel. Result is accelerated wear on both rope and guide-sheave flanges.

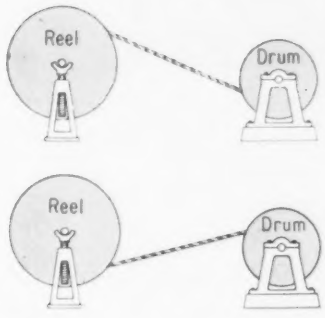
Worn sheaves and drums, guide rollers, etc, have a highly abrasive effect on new rope. Further, the more

Avoid kinks, reverse bends when taking rope from drum



Right

Spooling is best way to handle rope for service or storage. Use this method to wind from drum to reel



Wrong

Don't wind from top to bottom or vice-versa. If coiling rope on floor, be alert for kink-forming loops

the sheave or drum wear, the smaller its working diameter and the greater the departure from an efficient D/d ratio. Pinching effect, as we've seen, results in crushing and as bend radius gets shorter we come up against our old enemy, fatigue. Photo, p 122, *left*, shows what can happen to a relatively new rope operating over a too-small sheave. Such breakage and accelerated wear can cost more than replacing the worn equipment.

Crushing also results from using a rope that's more flexible than necessary. Replacing a fiber-core rope with one having a steel-strand or independent wire-rope core can stop severe crushing damage with no serious sacrifice of flexibility. There's no "give" to a steel core — strands can't be crushed into it as they can into a fiber core. More steel in the core also gives a 7½% stronger rope without increased size.

Running a close second in crushing resistance is flattened-strand type. Under strain or pressure, its keystone-shaped strands form a rigid arch and resist pressures that would flatten round-strand rope of equal size. Too, it packs 10% more steel into the same diameter with corresponding strength gain.

If you're faced with both crushing and fatigue damage, you've got to compromise. If fatigue damage is more serious than crushing, pick a rope construction more resistant to fatigue but having acceptable crushing resistance. Trick is not to overreach yourself in favoring fatigue resistance. If you do, you'll have a rope that's much too susceptible to both crushing and abrasion. The same is true, only more so, in striking the best balance between flexibility needed for fatigue resistance and ruggedness demanded to resist abrasion. Again, it's matter of compromise—see box, p 121, to get the characteristic needed for the particular application.

Reserve strength is combined strength of all the rope's wires *except* those in the outside layer of the strands. So the more layers (wires) a rope has, the greater its reserve strength. Reason: The smaller the outside wires, the greater the interior-wire cross-sectional area. This gives a strength reservoir because in ordinary use the outside wires are by far the most vulnerable to abrasion, wear and corrosion. This reserve can be seriously reduced by internal corrosion and by nicking inner wires at their bearing points. However, this can be counteracted by adequate lubrication.

A word about maintenance. This must include how the rope's used as well as serviced. We mentioned how sloppy operation can crush rope. Top photo, facing page, shows what happens when an overstressed rope is suddenly released. This "birdcaging" is the result of unnecessary brutal treatment. Center and bottom photos show importance of good lubrication. As with any machine, wire rope must have adequate lubrication to protect against wear and corrosion. Add good inspection practice to detect and correct faulty operation and equipment and you'll run small chance of premature rope failure.

Removing rope from operating equipment for repair or storage is necessary at times. How rope is handled can make or break its life span. Preferably, rope should be spooled on a reel as it comes off the drum. Drawings, above, show right and wrong ways of moving rope from drum to reel or vice-versa.

Kinks are wire rope's nemesis. Even in spooling, loops can quickly become kinks if you aren't careful. Be doubly careful if you have to lay the rope out on the plant floor. If you can't lay rope in a straight line, arrange it in a large circle or oval. If you have to use a series of U-bends, be particularly alert for loops.

For storage, use a reel if possible. Otherwise, store rope in a carefully made coil, lashed securely at several points. Protect it from rust and corrosion and cover it in a dust-tight manner. *Never* pile anything on top of a rope stored in a coil.

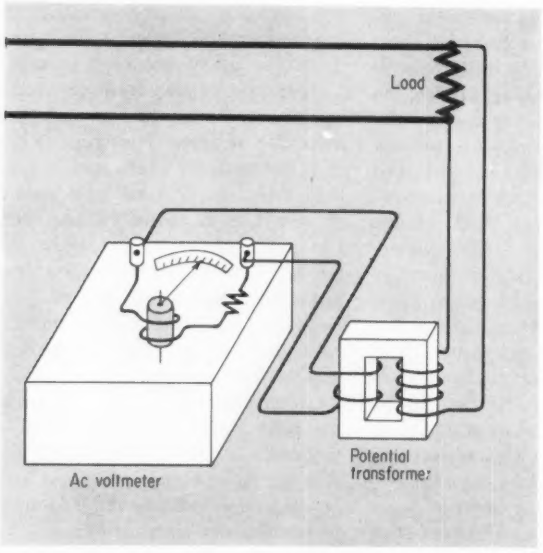
Plant Electrical Fact File

NO. 26: INSTRUMENT HOOKUPS

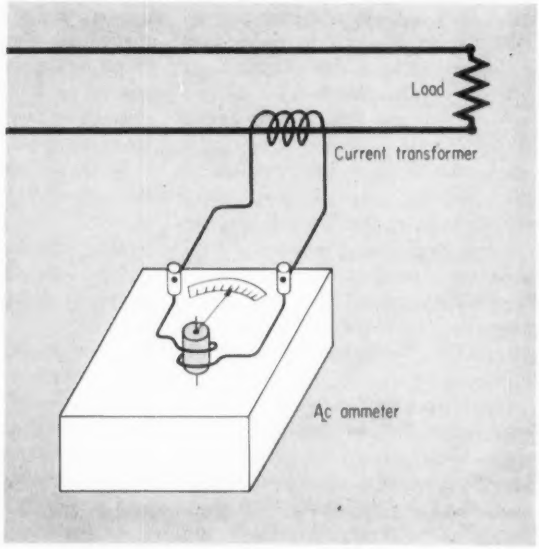
Tips on connecting ammeters and voltmeters

By NORMAN PEACH, Assistant Editor

Ammeters and voltmeters are the basic electrical measuring instruments. They're simple to hook-up, but a few precautions can improve accuracy of readings and prevent possible damage to the instruments. Never use an instrument in the vicinity of strong magnetic fields; for example, near cables or bus bars, or close to electrical machinery. Presence of a magnetic field which is affecting the instrument reading can be detected by turning the instrument 90 degrees at a time. If a different reading is obtained in the different positions, some stray field is present. Similarly, unshielded instruments should not be placed close together, nor should they be used on a metal table or other large metal surface. Instruments should be read in their normal positions. Check instrument zero settings, adjusting if necessary. But don't compensate for bent needle by changing the zero setting.

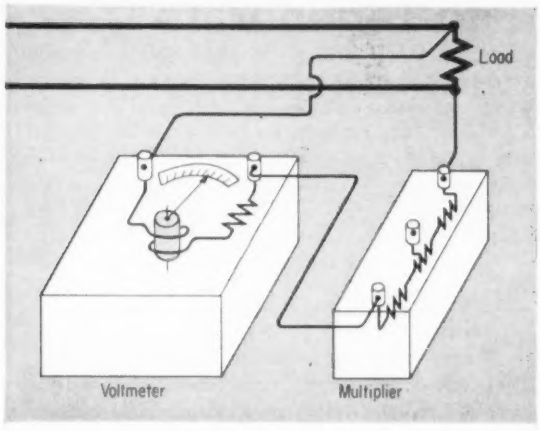


AC VOLTMETERS are usually connected directly across the line at voltages below 600 volts. At higher voltages a *potential transformer* is used. Always ground the potential transformer's secondary. Below 600 volts, a multiplier can be used to extend the voltmeter's range. A rule for all voltmeters: connect leads to meter before the line.

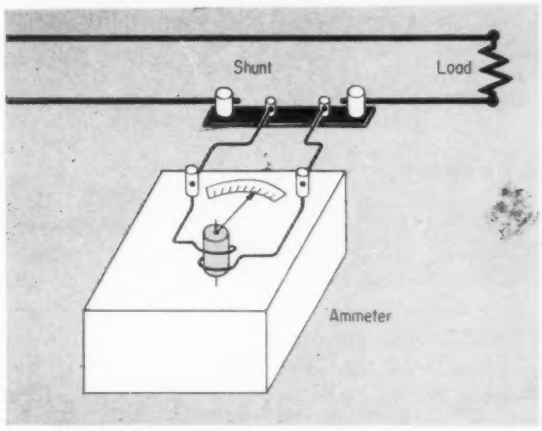


AC AMMETERS for smaller currents are connected directly in series with the load. For larger currents, a *current transformer* is used (*Fact File* No. 4, July 1956). Ground current transformer secondary; short-circuit the secondary when the ammeter isn't connected. Shorting arrangements should be closed when connecting in circuit.

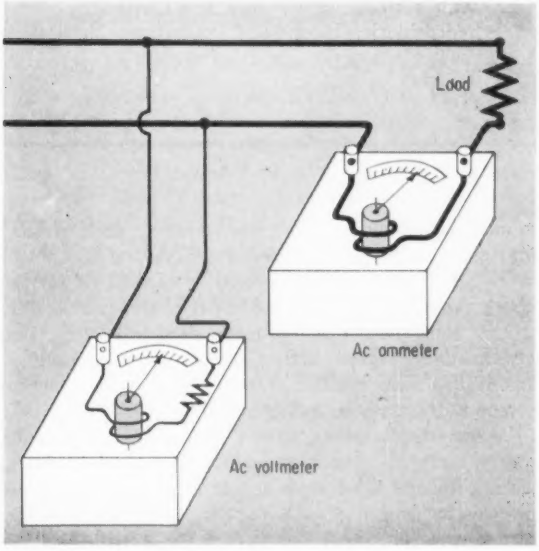
Direct-current instruments



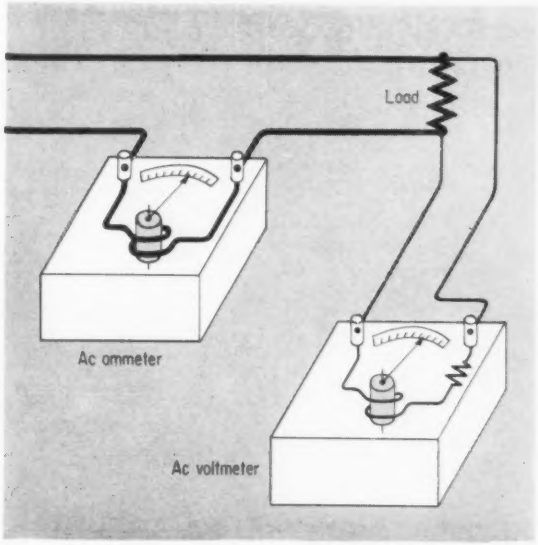
VOLTMETER has internal resistor; its resistance in ohms should be known. Range of voltmeter can be extended by using a *multiplier*, which is a series resistor. If external multipliers are used, check both the serial number of the multiplier and of the instrument to make sure that you are using the correct resistance combination.



AMMETERS, except for smallest, employ an external *shunt*. Instrument is really a millivoltmeter that measures voltage drop across shunt. Always use those instrument leads with which the instrument was calibrated. Terminals should be clean to avoid high contact resistance. Connect shunt in the grounded leg whenever it's possible.



AMMETER AND VOLTMETER are used to measure volt-amperes or kva. In dc circuits, or ac circuits with unity power factor, product of readings is equivalent to watts. In arrangement, above, voltmeter measures drop in ammeter as well as load; ammeter measures only load current. Hookup is suited to small currents, high voltage.



VOLT-AMPERES can be measured with ammeter and voltmeter connected so voltmeter reads drop across the load only. In this case, ammeter measures current in voltmeter's internal circuit, which is in parallel with the load. This hookup is suited to measurements in high-current low-voltage circuits. Meter loss can be found.

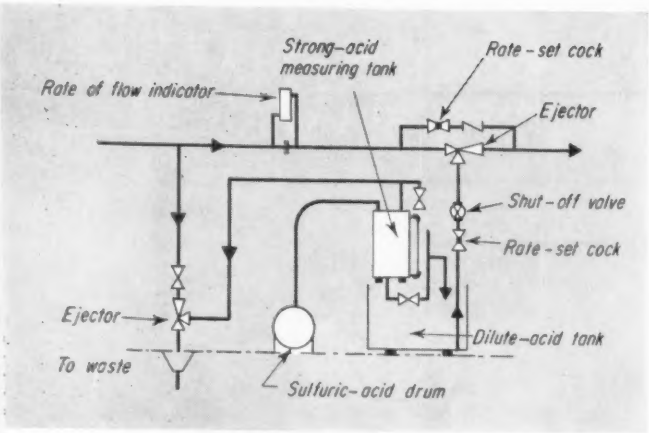
Ten ways to regenerate ion exchangers

By J S SAMKOFF
Instrumentation Section Manager
Graver Water Conditioning Co

No matter what kind of demineralizing system you have (POWER *TD* report, February 1958), successful operation hinges on correct exchanger regeneration. Consistent topnotch plant performance calls for regenerations that give (1) right amounts of chemical (2) proper concentrations and (3) enough contact time with exchangers.

Here are ten common ways of handling exchanger regeneration. Comparison of these methods is largely a matter of economics, although personnel safety, water quality and operating reliability enter the picture. Today's trend is to automatically controlled regeneration systems to get the reliable consistent performance that is often hard to obtain from the human operator.

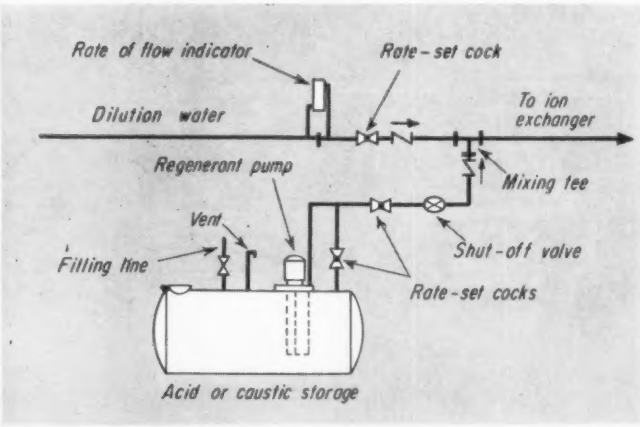
Cation exchangers are regenerated with acids such as sulfuric and, less frequently, hydrochloric. Strong-base anion units are usually regenerated with caustic.



1 HYDRAULIC EDUCTORS are one of the earliest methods of transporting regenerants. Water that actuates the ejector also serves as dilution water. Throttling plug cock, flow-rate indicator and maybe a pressure-regulating valve fix the flow rate to the ejector. It's possible to use a more elaborate flow control but this usually is good enough for most eductor systems.

Acid and/or caustic flow rate is also controlled by plug cock. Use an indicator to set flow rate or watch rate of drop in the chemical measuring tank. Controllers and control valves aren't very successful here because of unstable pressure and limitations on pressure drop in the ejector suction line.

Vacuum acid-handling system delivers acid from the carboy to the acid measuring tank. Correct acid charge can then be added to dilute acid tank below.

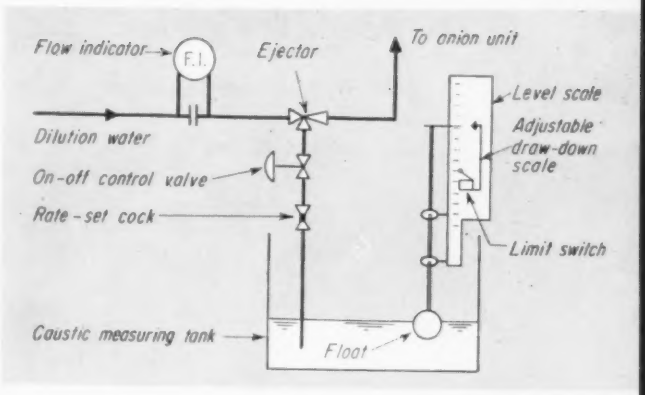


2 POSITIVE DISPLACEMENT PUMPS, either plunger or diaphragm type, are popular for small- and medium-sized exchangers where regenerant flow is moderate. For larger plants the cost is relatively high. Strong acid or caustic is pumped directly from bulk storage. Movement of dilution water through the mixing tee dissipates heat of dilution. Since concentrated (93%) sulfuric acid isn't too corrosive to iron and steel at ambient temperatures in a closed system, unlined steel tanks and piping can be used up to the on-off control valve. Check valve, plus tight seating control valve, prevents corrosion by keeping water out of strong-acid line. Another control valve is frequently used to vent the line between these valves during periods of no-acid flow. This is the most positive way to guard against severe corrosion from water leakage into the strong-acid line.

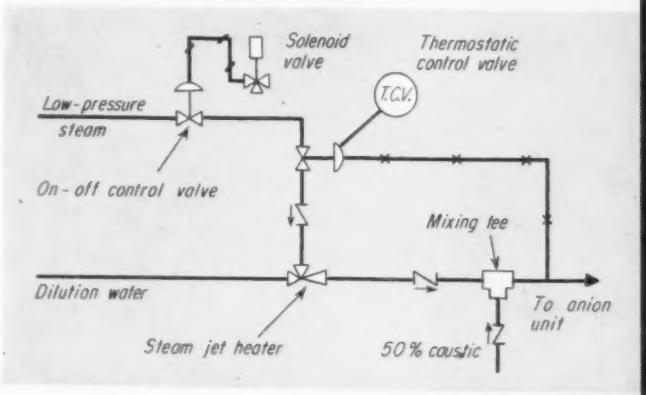
Positive displacement pumps give accurate flow-rate control, and with a timer it's easy to control total volume. Packing leakage is a trouble source unless right materials and packing are used. Diaphragm pumps are usually more costly but don't have to contend with packing troubles. Another recent development is a plunger type pump that operates completely submerged in the liquid. Packing leakage here is unimportant. Simplest way to control dilution-water flow is with pressure regulator, throttling cock and flow-rate indicator. Many plants include an electrical interlock to delay start of regenerant pump until dilution-water flow is established.

3 **CAUSTIC MEASURING TANK** dissolves a whole drum of flake caustic. This is usually enough for several unit regenerations. Float-operated limit switch on a sliding scale gives automatic control of the volume. Switch is then reset by hand. Another accurate low-cost method uses float switches or electrode probes. Big advantage of probes is comparatively low-cost corrosion-resistant construction. And they are well-suited for operation in either covered or closed tanks.

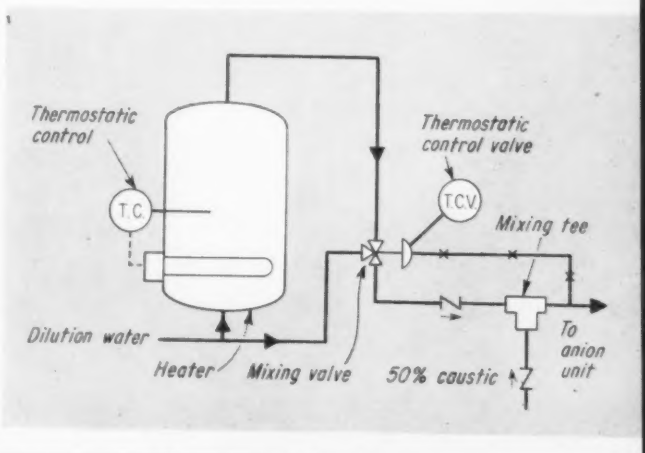
Initial popularity of ejectors was probably generated by their apparent safety. But hazards remain in preparing diluted chemicals, and reliability isn't up to automatic-operation standards. Ejectors are used chiefly on small manually operated demineralizers.



4 **STRONG-BASE ANION** regeneration with caustic soda is most efficient at temperatures in range of 100 to 120 F. Steam is the most popular heat source. Often it's mixed directly with dilution water in a jet type instantaneous heater. Sometimes a tubular heat exchanger is used. Hot dilution water from heater is added to concentrated caustic in the mixing tee. Temperature leaving this point is monitored by a direct-acting thermostat controlling a valve on the steam-inlet line. Pneumatic instruments are best on larger jobs or where close temperature control is needed. An indicating thermometer with high-temperature contact helps check system performance. More thorough supervision is obtained with a temperature recorder.

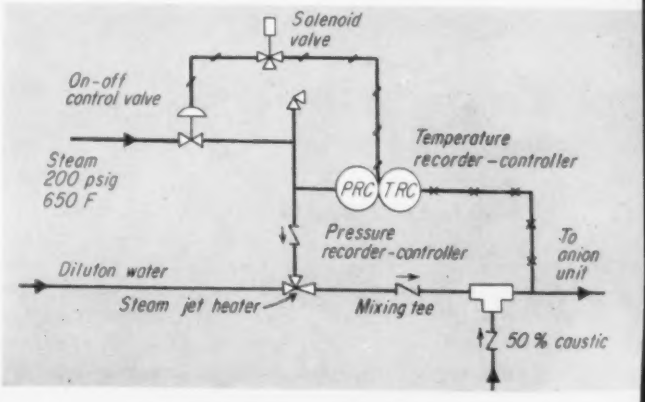


5 **ELECTRICITY** is also a good heat source for anion regeneration. Chief drawback to instantaneous types is high rate of power consumption. This can be avoided by heating dilution water slowly to about 200 F in a simple electric hot-water heater. An on-off electric thermostat gives sufficient control. This hot water in turn heats dilution water for regeneration. Temperature of dilute caustic leaving mixture tee is also monitored by a direct-acting thermostat. This controls mixing valve receiving both cold and hot dilution water.

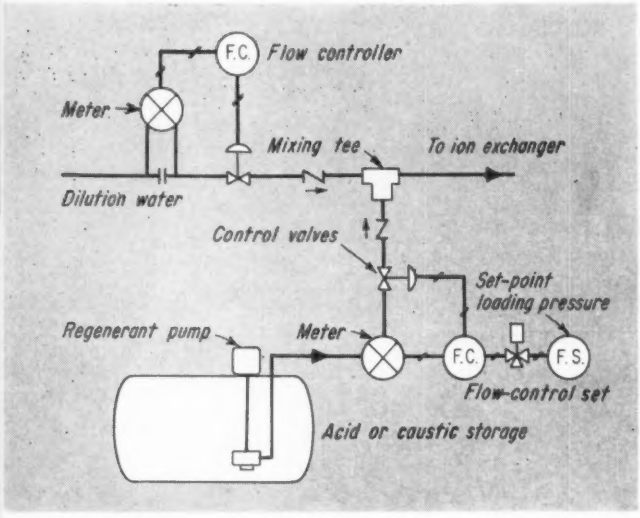


6 **STEAM PRESSURE** in this case is high enough to damage jet heater and other equipment in the system. Upon automatic cold-water start-up, temperature controller opens the steam control valve wide, putting system under full steam pressure. But, combination pressure and temperature recorder-controller prevents this and avoids expense of a pressure-reducing valve and larger steam control valve.

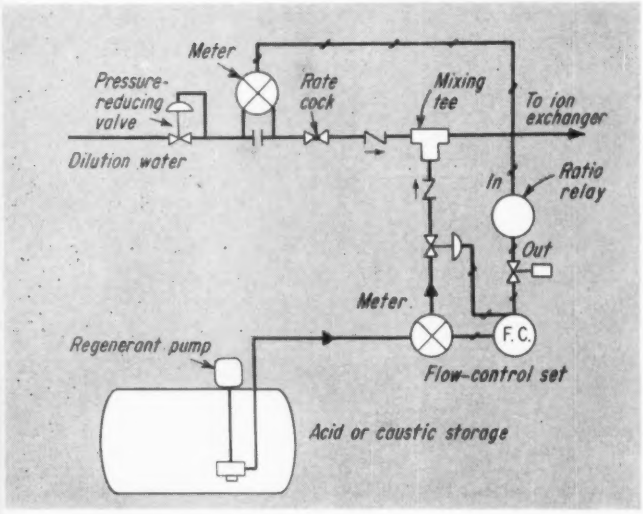
Temperature-measuring instruments for anion regeneration are usually filled-bulb type. Stainless-steel bulbs are best for corrosion resistance. They can be removed for periodic inspection during long and frequent no-flow intervals. So eliminate bulb protecting wells for faster response and better control of regenerant temperature.



Automatic control ups plant reliability, lowers operating cost

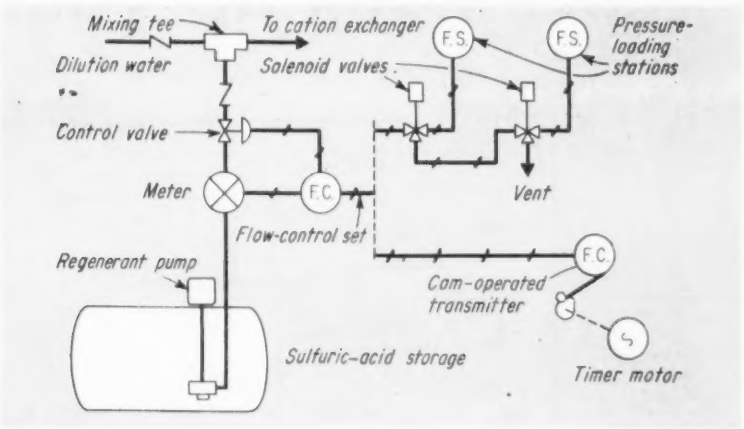


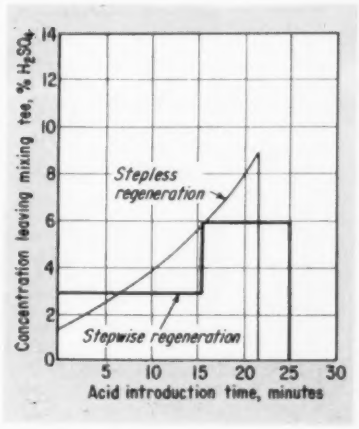
7 **CENTRIFUGAL PUMPS** are more often used to deliver concentrated caustic or acid in larger demineralizing plants. At flow rates above 2 gpm, positive-displacement pumps are expensive. Horizontal-shaft pumps with flooded suction have potential packing-leakage problems. So conservative approach calls for vertical-shaft pumps submerged in the liquid. Flow rate from positive-displacement pumps is easy to read and control with pump-stroke adjustment. Volume delivered is a direct function of time. But with centrifugal pumps additional equipment is needed. Rate of discharge is usually measured with a flowmeter. Variable area types are particularly good for moderate flow rates (2 to 15 gpm) and corrosive service; they handle liquids with moderately wide fluctuations in viscosity. Safety favors all-metal construction over glass-tube types. Transmitter, controller, etc, are actuated by magnetic linkage. If regenerant is HCl, cost for corrosion-resistant materials is high. More economical meter is diaphragm type differential-pressure cell protected by a liquid seal. Orifice plate producing differential pressure can be made of Hastelloy-B or Pyrex glass. Dilution-water flow is usually high enough to use on orifice type flowmeter. System shown has pneumatic flow-rate controllers for both regenerant and dilution-water flow to give right concentration in mixed stream. Timer controls total volume. Pressure-regulating and rate-setting valves are a low-cost alternate for dilution-water control with only a small sacrifice of accuracy in final chemical concentration. It's also possible to integrate strong regenerant flow for control of total volume, but this ups cost and is no more accurate than an ordinary timer with a flow-rate control.



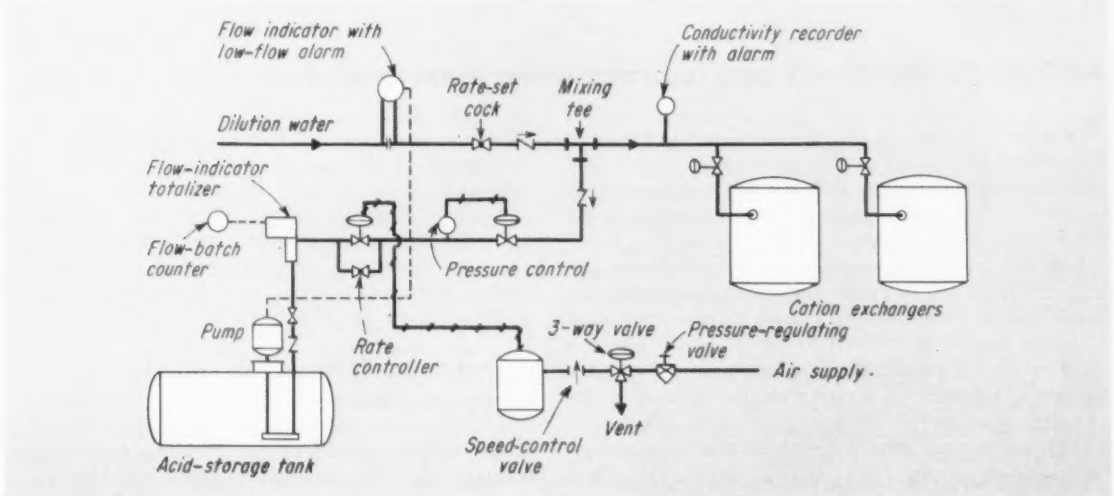
8 **RATIO CONTROL SYSTEM** with pneumatic instruments also has ability to produce wanted concentrations. But strong regenerant-flow will follow every variation in the dilution-water flow rate, so straight time isn't reliable for total volume. This means integrating strong regenerant flow. In one method the integrator is equipped with an electric switch that makes a contact every time a fixed number of gallons is totalized. These impulses are received by a preset counter with an electrical circuit that stops regenerant pumps when preset number of counts are registered. In another method, an electric switch on the integrator closes at equal time intervals. It remains closed for a period proportional to measured flow rate and intermittently drives a synchronous-motor timer. Timer setting is easily translated into a number of gallons totalized. Ratio control is useful for blending two streams in right proportion while total throughout varies with other factors such as demand. But for essentially a single-rate operation, demineralizer regeneration seldom justifies flow-ratio controls from a cost or operating standpoint. Flow-rate control is usually more than adequate and costs less. Electrolytic conductivity is a good way to measure dilute-regenerant concentration. Some European plants also use it to control strong-regenerant flow-rate. Volume control then is possible with either a measuring tank or a flow-rate instrument. Since flowmetering is required anyway, conductivity is more commonly used to check on flow controls. Instruments are available with alarm contacts to signal any off-the-beam concentrations. One popular and economical instrument is a manually balanced conductivity bridge that is convenient for spot checking.

Cation exchangers often call for unique regeneration systems





9 CONCENTRATION CONTROL of sulfuric acid for regenerating cation exchangers poses an interesting problem. Calcium ions present in most water supplies combine with sulfate ions to form calcium sulfate. This compound is not very soluble and often coats the cation resin. Result is poor water quality and loss of bed capacity on the next service run. Special hydrochloric acid wash usually cleans up the cation resin. Better answer is to introduce sulfuric acid at a low concentration (usually 2 to 3%) during first part of regeneration. Calcium sulfate is formed at low enough concentrations to remain soluble. After most of this is displaced from the cation bed, more acid is introduced at a higher strength (usually 4 to 6%) to complete regeneration. Chart shows a typical curve of concentration against time for this kind of "stepwise" regeneration. Compare this with smooth curve of chemically more efficient "stepless" regeneration. Controls for both methods are given on flow diagram. For a stepwise hookup, pneumatic-set flow controller receives two or more setpoint loading pressures selected by solenoid pilot valves. These are energized at the right moment by automatic-regeneration controls. For a stepless system, cam-operated pneumatic transmitter feeds a set-point signal to flow controller, giving the exact strength wanted. Cam, driven by a synchronous-motor timer, can be cut to any shape.

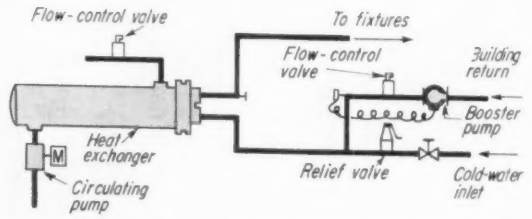


10 STEPLESS CATION REGENERATION can also be obtained by this method. Regulated rate-setting pressure is applied directly to the control valve through a speed control valve and volume chamber. Controlled pressure conditions help maintain correct flow rates. Acid flow is integrated for volume control. But this control does not give a straight-line relationship between the valve stroke and time. Use of a control valve with equal-percentage plug will help straighten out the plot of acid strength and time. Even so, the result is usually a compromise with the optimum. But it can be used if desirable to modify existing systems or if conditions call for it.

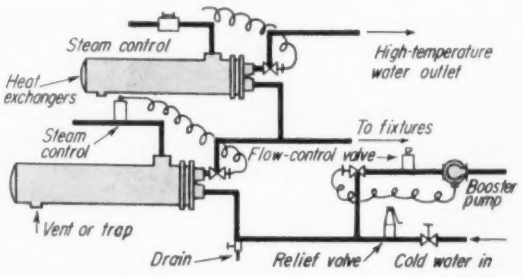
OPERATORS' NOTEBOOK **119**

Let's hook up your

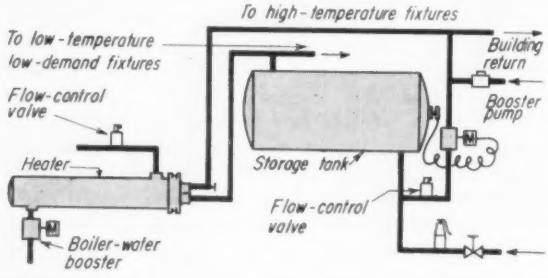
Here's how to install indirect water heaters



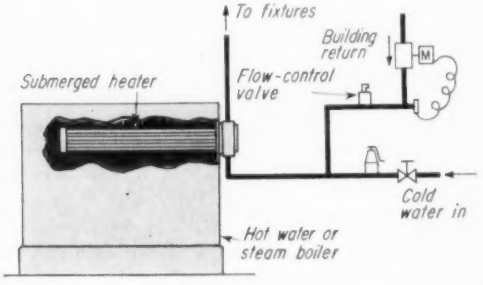
INSTANTANEOUS HOOKUP for indirect water-heater systems uses either pumped boiler water or steam as the heating medium



TWO TEMPERATURES of hot water—large volume in 140-F range, small volume in 180 to 200-F range—often are needed in buildings



SEMITANKLESS installation provides large volumes of extra hot water that periodically are in excess of boiler and heater capacity



ECONOMICAL instantaneous hookup has a heater in the boiler's water chamber. Coils are installed below water line in boiler

And here's the direct and indirect water-heater picture

Water heaters come in two classes: direct and indirect. Direct-fired units, such as gas heaters and small boilers, heat by direct application of flame. Indirect heaters heat by transfer of heat through copper tubing from hot water or live saturated steam.

Indirect heating has some important advantages:

1. It furnishes hot water the year around from the same boiler that provides for space heating or process work.
2. Initial cost of an indirect heater is usually less than the cost of a direct-fired unit of equal capacity. Too, because of high-efficiency rating of most heating boilers, operating costs are less.
3. Indirect heaters need no separate fuel, electrical or chimney connections.
4. All water heaters must be cleaned periodically to maintain proper heating efficiency. But, because the heating surfaces of indirect units are not subjected to high surface temperatures produced by a direct flame, there is less tendency for deposits to precipitate out of the water being heated. For this reason indirect water heaters don't have to be cleaned as often as direct-fired units.
5. Indirect water heating is best suited to large buildings such as apartments, hotels, industrial buildings and institutions of all types. Usually the hot-water demand in these buildings is heavy. Therefore, the most practical and economical heat source is the main space-heating boiler for the building. Most space-heating boilers used in large residential and commercial buildings have enough heating capacity to provide the entire hot-faucet water needs on an instantaneous basis.

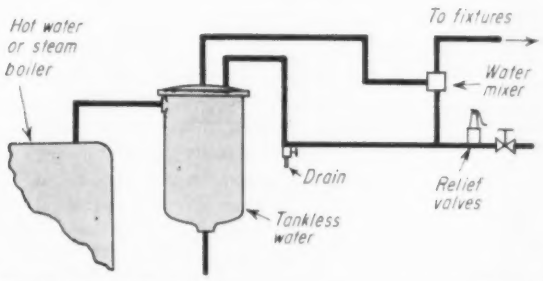
Direct versus storage operation

Indirect water heaters are available for use with or without storage tanks. Storage-tank installations require less boiler capacity, therefore have smaller indirect heater than tankless- or instantaneous-heater installations. But there are many places where direct heaters can be used more effectively and economically than a storage type unit.

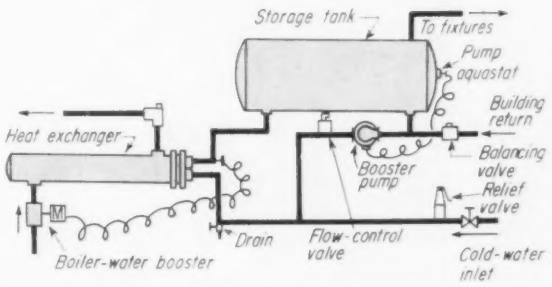
Lower cost. Biggest savings is because tankless system doesn't need a hot-water storage tank. This can save hundreds, or thousands of dollars initially. Too, because of small size of tankless job, amount of standby-heat loss is reduced, cutting operating costs. When built-

indirect water heaters right

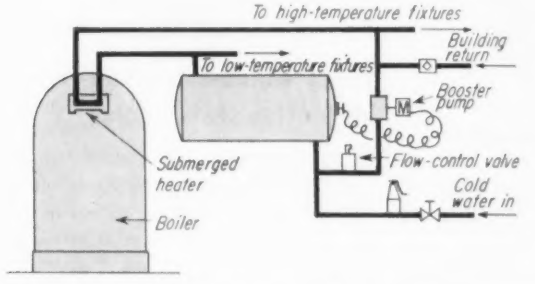
By STEVE ELONKA, Associate Editor



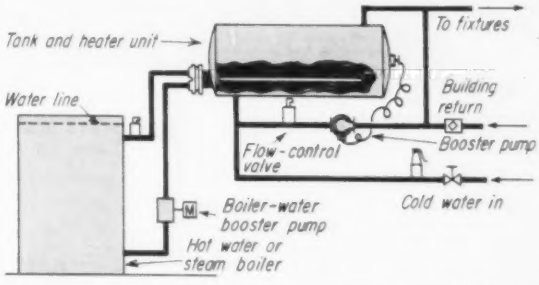
SMALL VOLUMES of hot water are gotten instantaneously with this tankless hookup. It is usually best for very hard water



HEAVY RATES of draw hookup are in excess of the boiler's capacity. On draw, cold water enters heater instead of going to the tank



ANOTHER economical hookup gives fast temperature pickup and circulated building returns, allows you to floor mount tanks



MORE HEATING and operating economy is obtained with booster pump hookup, but tank and heater installation isn't instantaneous

in or submerged direct heaters are used, costs are slashed to an even greater extent.

Efficiency. Instantaneous heaters can be installed so the water is heated only as it's needed. They can also be installed in conjunction with smaller storage tanks on a semitankless hookup. Instead of heating the tank by gravity circulation, a booster pump is used between the heater and the tank. Booster pump helps to reduce size of heater, tank and piping. By increasing heating efficiency it reduces pickup time. Booster pump increases heating efficiency and thereby reduces costs.

Versatility. Commercial and industrial processing applications require higher water temperatures than are normally needed for general use. But with a storage system the higher water temperatures often make it necessary to use special tank linings. Direct heaters can be installed so hot water at different temperatures will be supplied as needed without the need of storage space.

Less maintenance. Instantaneous type heaters are a blessing to both the building engineer and the owner. For the building engineer, periodic back-flushing by means of a few valves is all that's needed. There's no lengthy shutdown period, no messy cleaning and repairing jobs and no waiting for reheating.

But, despite all the apparent advantages of direct heaters over the storage tank type, there are two very important limitations to the instantaneous method: (1) Use them only when adequate boiler-heating capacity is available and (2) don't use instantaneous water heaters in extremely hard-water areas except where water filtration or softening is used.

Where do you use which heater?

When adequate boiler capacity is available and unless water hardness is a restricting factor, the indirect heater (in either internal or external models on an instantaneous hookup) is usually a practical and economical method of heating. Even more effective for many buildings is the semi-tankless installation. This uses both an instantaneous heater and a small storage tank interconnected by an all-bronze booster pump.

For more information on this subject, request 8-page bulletin *Instantaneous Water Heaters* from the Bell & Gossett Company, Morton Grove, Illinois.

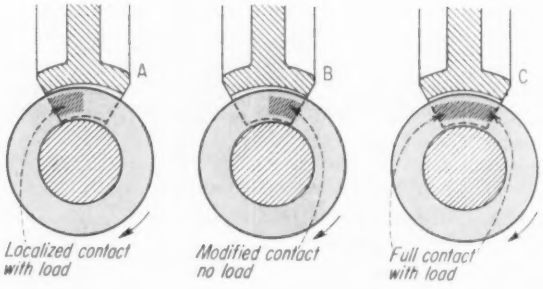
Timely **practical ideas** to help solve

Hypalon-jacketed wire resists corona, ozone

Photo shows Hypalon-jacketed wire being assembled into an ignition harness. This new wire is designed to meet military specifications for Class-C cable. It has a temperature range of –65 to 250 F. Cable is 5 mm, rubber insulated, reinforced with a glass braid and covered with Hypalon, the new jacketing material.

Jacket combines low-temperature properties with corona and ozone resistance. Ignition harness assemblers report good results with the handling properties of the new wire. Its insulation strips easily and the wire is readily assembled into the completed harness. Wire is now used in aircraft, tanks and landing craft.

—Courtesy, E I DuPont de Nemours & Co, Inc, Wilmington 98, Delaware.



Worm-gear contact modified for distortion under load

Blueing the worm of our heavy-duty worm-gear reducers and locating the gear by either adding or removing shims to give full contact before installation wasn't always satisfactory. The three sketches, above, show the steps we've taken to solve our problem.

As shown exaggerated at *A*, deflection of bearings, shaft and housing under load causes an axial or tilting movement of the gear. This produces a localized contact between worm and gear, influencing the performance of the reducer.

Now, with attention to the direction of rotation of the worm in service, we deliberately offset the gear from the worm by moving one or two of the thin shims from side to side of the housing to give localized contact, as shown at *B*.

This balances the distortion and gives full contact between worm and gear under load, as shown at *C*.

E WITTMANN, *Villas, N. J.*

Dirty windows traced to defective steam valve

Window cleaners in a multistory office building found that during winter months, inside surfaces of windows on the fourth floor were repeatedly coated with a film of oil.

All floors are served by individual air-conditioning units, each equipped with automatic oil-bath filters. Since all are alike and only one floor was affected, the filters were not considered as a source of oil. Reason was that interior surfaces of all ducts were clean and there was no evidence of oil carryover.

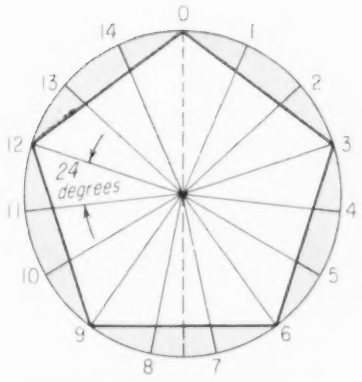
Source of trouble was discovered accidently while the fourth-floor unit was shut down over a weekend. A trickle of what appeared to be smoke was noticed at a return air grille. An immediate check showed that the entire return-air compartment was filled with bluish smoke from an overheated oil-filter screen.

Heating coils are installed in bypass position above a cooling coil, close to the filter panels. Normally, steam valves close when the unit is off. In this instance, a valve stuck open and overheated the filter compartment to the point where oil vapor was released. Repairing the valve corrected the overheating during shutdown periods. This ended the window-cleaning complaints.

E F WEHLAGE, *Fairport, N. Y.*

your tricky design and maintenance problems

STEVE ELONKA, Associate Editor



Here's a better way

In POWER, March 1958, p 142, J De Hass told how to divide a circle into five equal parts. I believe I have a faster and equally accurate method.

First, scribe a circle, sketch. Then draw a perpendicular line. Next find fifteen equal parts of the circle. Do this by dividing 360 degrees by 15, which gives you 24 degrees. Lay off these 24-deg lines with protractor. Next draw lines at rim of circle through every third degree line where it intersects the circumference. Result is five equal sides. You can divide a circle into any number of divisions by this method.

W DICK, *New York, N. Y.*

Insulate those pliers

Pliers are commonly used to hold small parts in position for soldering operations. We find that a piece of asbestos tubing slipped over each jaw, sketch, improves the operation. The asbestos prevents the pliers from drawing the heat out of the parts. This tends to keep the work hot and the handles of the pliers cool.

E JONES, *Bronx, N. Y.*

What would you have done?

I thought I had my fill of improvising to keep machinery running at sea. But I tackled one of my toughest problems at a rubber plantation in Ceylon.

We had a single-cylinder, 4-cycle, 5-hp 120-rpm diesel engine driving a small gear pump. This pump supplied water for living quarters and various plantation needs. The pump was below a dam and forced water up to the supply tank.

One day the engine failed. After taking it apart I found the piston cracked into three pieces. There was nothing to do but install a new piston. Only trouble was we'd have to wait eight weeks before a new one would arrive from Singapore. What to do? That called for ingenuity because we couldn't get along without water.

The piston was 7¾-in. diameter. But only material I could find of that size was teakwood. So I carved a piston out of teakwood, put on two well separated rings and started up.

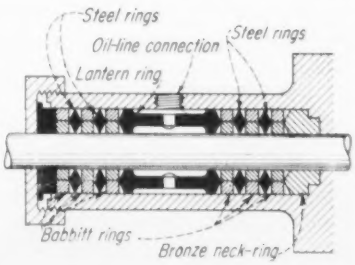
After 50 minutes the piston failed. But I had a second teakwood piston ready. This time I screwed a steel plate on top to protect it from the direct heat of combustion. But it didn't last as long because the plate concentrated heat below it on the piston and heat collected by plate couldn't be carried away quickly enough.

After making a third teakwood piston I ran the engine for only 10 minutes, then shut it down for 15 minutes. By this intermittent operation, each teakwood piston lasted 20 to 30 operating hours.

A series of teakwood pistons kept things running until the new piston and spares arrived. What would *you* have done?

P HOBSON, *Concord, Calif.*

This CO_2 compressor packing does the job



POWER, Oct 1957, page 130 shows CO_2 compressor packing that solved an annoying problem. My sketch shows packing set that has been used successfully in these compressors for years. Pressures are often over 1200 psi and the wrong type packing can cause a lot of trouble.

J DEHAAS, *Seattle, Wash.*

Turn page for more Practical Ideas ►

Now, infrared lamps preheat for welding

You boys who are familiar with welding heavy machinery know the value of preheating before and during a welding job. Preheating greatly lessens the possibility of any under-weld cracks developing, especially on the heavy welds on cold pieces.

In the large welding shop, preheating is done with oxyacetylene heating torches, natural gas and kerosene "hog-burners."

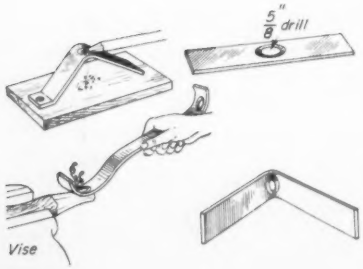
Recently, while welding a pitted turbine runner weighing 40 tons, the question of preheating came up. The weldor in charge insisted that some form of preheating be done. It was November and the temperature in the scroll case of the turbine was 38 F.

Since the welding was being done without removing the runner from the scroll case, preheating with any medium that gave off fumes was impractical because of health reasons.

Photo shows how the problem was licked. Batteries of 150-watt infrared lamps were installed some 6 to 8 inches from the runner blades, and about 20 inches from the weld area. Temperature was raised from 38 to 140 F, which was enough for the low hydrogen rod used on the job. This also permitted the weldors to do their work in greater comfort.

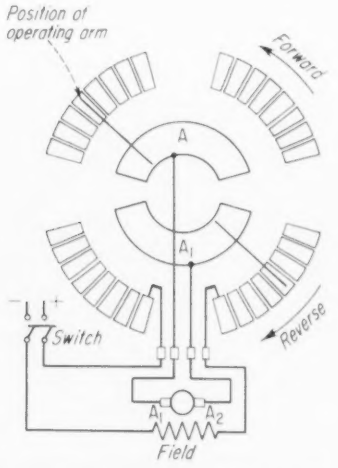
L C McWilliams, *Shawinigan, Que.*

Draw shave for small work is easy to make



If you have to fit a hammer handle and have no rasp or regular draw shave, just look around for a piece of flat steel stock. Drill a part hole in it; about a ⅝-in.-dia drill is best. Drill about two-thirds of the drill diameter, smooth off the burr to present a sharp edge and bend to needed shape. Sketches show device used as a double-ended draw shave.

C H Willey, *Penacook, N. H.*



Speedy emergency repairs for dial controllers

Many shop machines and cranes still have the old style dial controllers. For crane service the slate dial surmounts the hollow cast-iron stand containing the wound Nichrome wire resistors. With time, corrosive factory atmospheres take their toll. Also, the contraction and expansion in combination with rough-riding truck wheels cause these resistor coils to break. Getting at the outer rows is not too tough, but the inner banks are a problem. Fact is that permanent repairs to those units mean a between-shift or week-end overhaul.

We have a method that not only works, but gets the old equipment back on the line in jig time. We remove the four countersunk bolts holding the brass contact plates on each side of the open circuit resistor (the arcing tells the tale). Then we insert one thickness of brass shim stock cut to match the size of bolt holes of two contact plates.

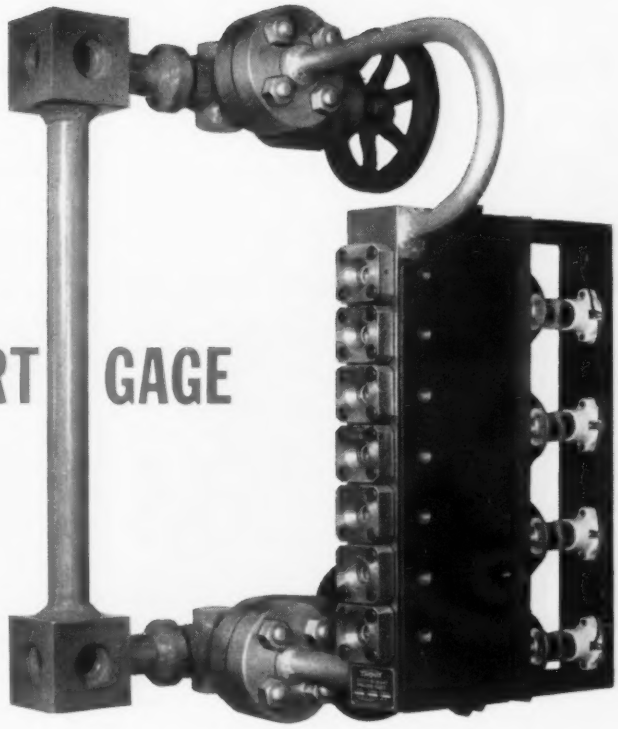
With the shunt in place, the crane runs as of old and a permanent repair can be made.

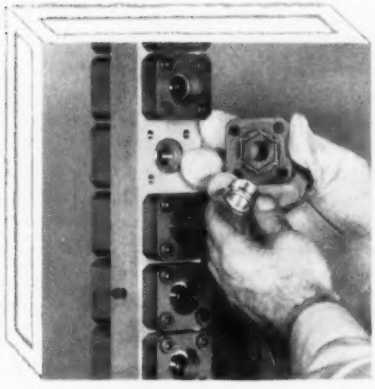
P C Ziemke, *Clinton, Tenn.*

My biggest boner

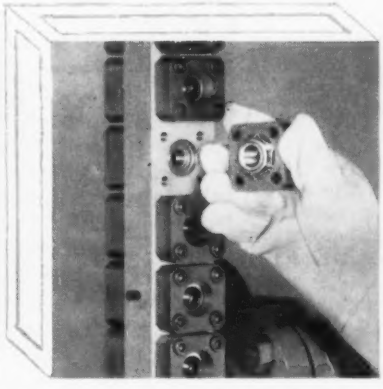
Please turn to page 174

servicing the new YARWAY COLOR-PORT GAGE is easy as a b c

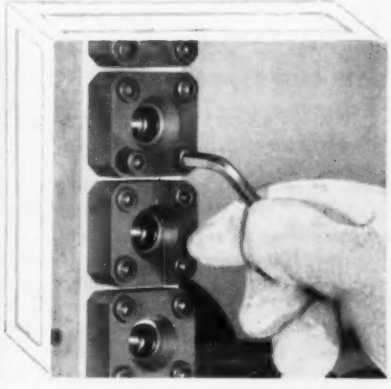




a Remove four Allen cap screws and lift off cover assembly. Replace port assembly (glass-mica-gasket assembly) in cover.



b Re-install complete cover assembly. Sealing gasket automatically seats in gasket groove in body.



c Tighten down four Allen cap screws with standard wrench (no torque wrench required).

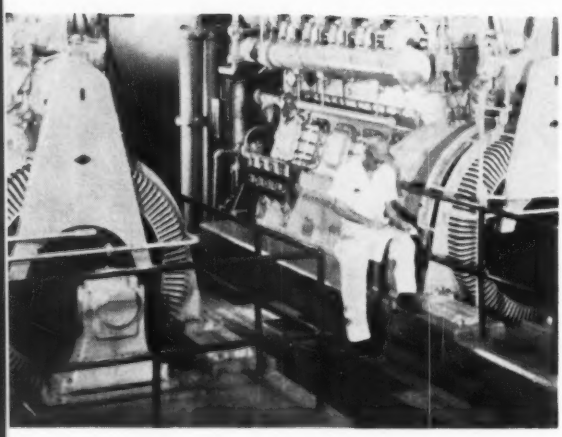
New Yarway Color-Port Boiler Water Level Gages (for pressures to 3000 psi.) offer not only this new ease of maintenance but insure brilliant red and green readings of steam and water.

For full details, write for Yarway Bulletin WG-1814.

YARNALL-WARING COMPANY, 100 Mermaid Ave., Philadelphia 18, Pa.
Branch Offices in Principal Cities

GO YARWAY WITH CONFIDENCE

These **plant problems** could well be yours...



The problem

How can synchronizing voltage-regulator accidents be avoided on engine-generator sets?

What happens if a breaker on an engine-generator set accidentally closes in on the bus 180 degrees out of phase with another engine-driven generator already on the bus? Our plant includes a 1000-kw vertical uniflow, two smaller horizontal nonreleasing corliss units and a belt-driven unit; generating at 4160 volts. What happens if a voltage regulator fails in such a manner as to remove all resistance when a single generator is supplying the bus? We normally run with the main and exciter-field rheostats in the "all-out position." Our voltage regulators consist of two rocking-contact, a silverstat and a carbon-stack type. Have readers had such experiences? What precautions can I take to avoid these accidents?—*CRB, March* POWER

The solutions

You must fully understand your system

If the larger generator is fully loaded, *CRB* will find resultant short-circuit current exchange between machines will open their breakers. Peak magnitude of resultant current depends initially upon subtransient reactances of the machines in parallel. Maximum stress and deflection of mechanical members, shafts, windings, etc. is imposed during this period. After a few cycles, short-circuit current declines to a lower value fixed by transient reactance of the machines and interrupted by the breaker. Energy released during these few cycles must be dissipated, so all mechanical parts are liable to damage. Heavy flywheels tend to protect the prime mover.

Paralleling an ac generator with others feeding a load is comparatively easy with present-day equipment. But it's still a responsible job calling for complete understanding of the principles involved. Closing a generator out of phase is usually carelessness by the operator. Generally the phase-angle difference is small and the machine is pulled into step without undue mechanical stress or electrical surging. But when paralleling is attempted 180 degrees out of phase, look for an undetected fault in equipment or wiring rather than a human error. Avoid trouble by making rigorous periodic checks on the overall system.

Voltage regulators control generator-field excitation within limits set by the exciter and generator-field rheostats. If there is complete shunting of the voltage-regulator resistance element, generator-field current will be at a maximum with resulting line overvoltage. Amount of this rise depends on the distribution-system elements. Lamp life will probably be curtailed. Although voltage-regulator failures are not common, it pays to maintain these items in good condition to avoid trouble.

J WHILEY, *New York, N. Y.*

All generators will probably trip out

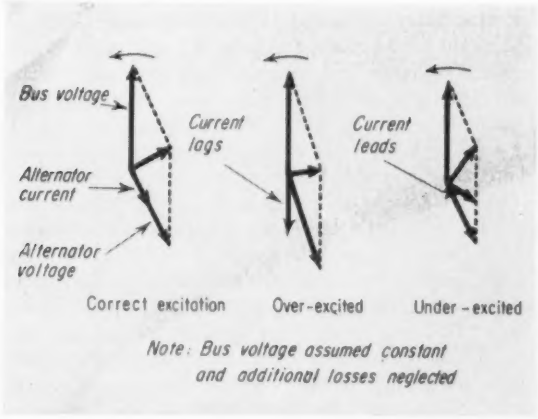
It's hard to say what happens if a circuit breaker closes a generator in 180 degrees out of phase on an energized bus. A smaller generator closed out of phase usually pulls itself in. Chances are that if the 1000-kw generator is added to the bus under these conditions the other units will trip out. It's even more likely that *all* units will trip out. If one generator remains connected it will probably be overloaded and relayed off the line.

Accidental removal of the shunt-field resistance by failure of the voltage regulator causes maximum excitation resulting in bus overvoltage with low lagging power factor. Short circuiting of exciter shunt field results in no excitation and no generator output.

H JOHANSON, *Estevan, Sask., Canada*

...Here's how *Power* readers would tackle them

ROBERT MARKS, Assistant Editor



Regulator failure ups field current

If *CRB's* voltage regulator hangs up, field current will increase and steady-up at a higher level. Amount of increase is fixed by design of the instrument, exciter and alternator. If there is no resistance in the circuit and power input is constant, excitation will increase and produce the lagging power factor shown above. If all circuit resistance is in phase, excitation decreases to give a leading power factor.

Any alternator switched out of phase into a power system will be pulled back into phase with all energy available in the system. I have seen results of this on several occasions. One incident was caused by a synchroscope wiring error. When the synchroscope lamp is bright, machine is in phase; if dark it's in opposition. But in this case the lamp showed bright when it should have been dark. Result: a broken crank on the diesel and displaced generator windings.

Another accident happened to a firm that bought a diesel-generator set from war-surplus stock for peak-load operation. It was set up by an operator who didn't know that the governor had to be reset for the new frequency. He closed it in on their 60-cycle system, wrecking the coupling and twisting the diesel crankshaft.

P D HOBSON, *Concord, Calif.*

Synchronizing calls for steady nerves

Sloppy synchronizing is almost a sure way to damage ac power units. In two cases I've seen generator shafts that had to be returned to the factory for straightening and rebalancing. In another, a heavy tandem-compound medium-speed engine generator received a sprung crank that eventually had to be replaced.

Synchronizing generator units is a risky procedure at best. It calls for practice, steady nerves and quick reactions. Allowance must be made for any inherent time lag in the switching mechanism. And don't forget to allow for your own reaction time. It's usually best to have the incoming unit on the fast side with movement of the synchroscope not over 20 rpm. Start to close the switch when the pointer is within $\frac{3}{8}$- to $\frac{1}{2}$-in. of the zero mark. It's also a good idea to keep speed-changing devices in good working order.

Voltage-regulator failure in *CRB's* case, operating on a light load with all resistance cut out, can be quite serious. He will probably lose all his light bulbs and have a lot of punctured coils in solenoids, motors and transformers. Extent of the damage will depend on system reactance and how soon the operator is able to correct the situation.

We always keep enough resistance in the generator fields for minimum exciter voltage of about 80% normal. Cut out just enough exciter-field resistance to hold generator voltage on the peaks. Then response to regulator demands will be quicker with minimum voltage rise in case of failure. When ac generators are operated in parallel, additional adjustment of individual generator fields may be needed to equalize power factor and prevent objectionable cross currents.

M A JENSEN, *Lincoln, Neb.*

Always tell operators what can happen

Closing the breaker between two live alternators 180 electrical degrees out of phase has serious consequences. Even if the breaker does not blow up, generator windings and cables experience short circuits just twice that of a cable short. When two ac sine waves are 180 degrees out of phase, alternator voltage will be twice normal. If the circuit breaker holds, this abnormal exchange of current between alternators can damage windings, flywheels and other parts as the smaller unit is jerked forward or backward into synchronization.

Failure of *CRB's* voltage regulator allows the exciter to build up high dc voltage. This subjects the main generator field to an abnormally heavy current. Dangerously high voltage created in the stator coils of the alternator leads to insulation breakdowns in both alternator and external load.

In our own experience, the exciter-field rheostat is either "all in," or "partly in" and the voltage regulator bypasses the rheostat to keep proper exciter voltage. Generator main-field rheostat is usually set so the voltage regulator carries a stable exciter voltage. Good maintenance, inspection and personnel instruction are the best safeguards against these troubles.

C DEMERE, *Memphis, Tenn.*

Turn page for info on water treatment and new problems ▶

The problem

Shall we use evaporators or demineralizers for makeup treatment?

Our engineering department is designing several new central-station power plants. Part of my job involves handling the makeup treatment. We have always used evaporators in our previous systems and are well satisfied with their performance. But many central stations are now using demineralizing equipment. I know demineralizers produce excellent water. But the latest evaporator designs seem to do an equally good job. What are some of the most important factors that should be considered in evaluating the merits of these two methods of makeup treatment What is the best place in the cycle for the evaporator? Where should demineralized water be added? I'd like to hear how others would tackle this problem.—*SJD, March* POWER

The solutions

Want some help on plant problems? Send us any of your design and operating headaches. We'll put *Power* readers to work on them

Economic evaluation gives the answer

SJD's choice lies in an economic evaluation of total cost for evaporator compared to a demineralizer including cost of chemicals, steam and power. Initial price is often higher for large and complex demineralizers located away from the immediate plant area. And this equipment must be protected from the elements. The evaporator can be located anywhere, preferably at the point where makeup is added to the cycle.

One advantage of evaporators is low maintenance. Except for periodic blowdown for tube-bundle cleaning very little else is needed. Evaporator makeup can take fairly high dissolved solids without affecting daily operation or output quality. But demineralizers call for almost constant monitoring of water quality entering and leaving. Variations in analysis can alter treated-water quality.

For supercritical-pressure plants water quality is extremely important. And both methods are capable of meeting these purity requirements.

Evaporator makeup is usually put in the cycle at the deaerator. Heat in vaporized makeup is transferred to incoming condensate.

The demineralizer operates independently of the feedwater cycle. Its design is based on optimum load. Treated water is fed to a large storage tank and added to the system as needed. Most plants pipe it to a deaerator, although it can be sent to the surface condenser.

Both a demineralizer and an evaporator can be used in series with the demineralizer feeding the evaporator. Top-quality water is produced but cost of the overall water-treatment plant is greatly increased.

P GARCIA, *Los Angeles, Calif.*

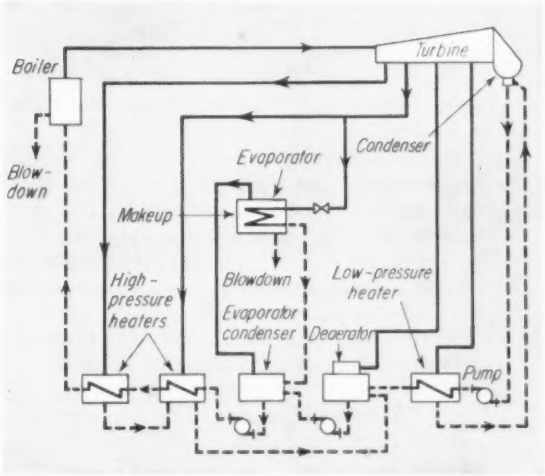
Send treated makeup to main deaerator

Operating cost for demineralizing depends on amount of dissolved solids in the raw water. It also depends on the cost of sulfuric acid and sodium hydroxide. Chemical cost of treated water may be in the range of 20 cents per thousand gallons. Distilled water from evaporators and condensers ranges from 50 cents to ten dollars per thousand gallons depending on dissolved solids present and number of evaporation stages.

Steam for evaporator operation is usually bled from the turbine. Vapor from evaporator is used to heat cold feedwater makeup in a heat exchanger or condenser. Resulting pure condensate is then added to the main-cycle deaerator.

Treated water in either case should be sent to the deaerator. Flow is usually regulated by a float-operated level control and mixed with condensate coming from the condenser via the low-pressure heater stages.

L E POLIKOFF, *Bethpage, N. Y.*



Here's one way to hook up evaporator

Flow diagram, above, shows evaporator in a typical feedwater cycle. In this hookup an evaporator condenser is used to receive both vapor and coil drains. An alternate arrangement sends vapor and coil drains directly to deaerator. Exact hookup used in each case depends upon the amount of makeup needed and the overall economics of the power-plant heat balance.

Vapor quality guarantees are usually limited to a solids content in the range of one ppm, although this can often be improved when the need arises. Actual value is influenced by type of separator used to remove solids from the vapor after it leaves the disengaging surface in the evaporator shell. For optimum performance: (1) Install evaporator with design capacity as high as 400% of the estimated feedwater makeup. (2) Select a feedwater cycle that doesn't affect evaporator performance as turbine load changes. (3) Pretreat water if necessary for trouble-free operation. (4) Operate evaporator at optimum load, water level and liquid concentrations.

H B Wayne, *Woodhaven, N. Y.*

Water analysis plays important role

Best way to decide this problem is to investigate the overall economics for each method. Estimate fixed investment, operating charges, depreciation schedule and maintenance costs for each method over estimated life.

Basic choice depends heavily on the analysis of the makeup water. If the makeup water is relatively low in total dissolved solids, demineralizing is easily done at low investment and operating cost. When the makeup water contains a high quantity of dissolved solids, it's probable that an evaporator will be more competitive.

R E Driscoll, *Channelview, Texas*

Both treatment methods do a good job

Either system *SJD* mentions will be satisfactory if water supply is analyzed and equipment properly designed for the job. Water supply and variations in its analysis are your principle problems. Make sure your physical layout is suited for either installation.

My preference is for an evaporator using turbine-bleed steam with connections for independent operation in case of turbine shutdown. It's my guess that life of evaporator equipment will be much longer than a demineralizing setup. An evaporator system, properly serviced, will give good water almost indefinitely.

C G Howarter, *Canton, Ill.*

Your June problems

What can we do about hot bearings on our air compressors?

I'm shift engineer for a manufacturing plant that uses quite a few large air compressors. The oldest machine was installed about ten years ago and the others are almost the same vintage. Lately, we've had a lot of trouble with hot compressor bearings and haven't been able to come up with a solution. Every time this happens we slow the unit down and flood the bearings with oil to reduce temperature. But we still don't know when it's safe to stop it entirely. So far none of the bearings have seized. Is there a rule of thumb we can use as a guide? Will new bearings in another material solve our problem? What other factors are important in the overall picture? These are only some of the questions running through my mind. Any suggestions will be greatly appreciated.—*JV*

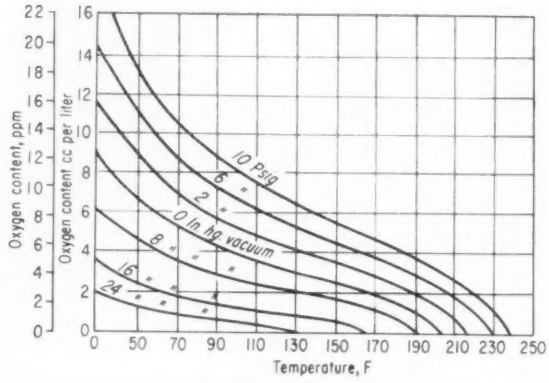
What's the best way to install globe valves?

As plant engineer it's always been my practice to install globe valves with incoming flow putting pressure on bottom of the valve seat. But in our recent plant expansion all globe valves were arranged so that incoming flow is on top of the seat. At this point I'm a little confused. Did our contractor make a mistake? Does the direction of flow make any real difference? Will it have any effect on valve operation and maintenance? What is the best way to hook up globe valves? I'd like to hear how other Power readers handle this.—*EPH*

Sit down right now and answer one or both problems. We'll pay extra for answers with photos or sketches

Your page for **comment**

BOB BELLAS, Assistant Editor



Consider chemical deaeration, too

As pointed out by Mr Schaub's article "Deaeration for the small plant" (POWER, April 1958, p 118), desirability of proper deaeration is recognized by the plant designer. And where mechanical means can be justified economically, it should, of course, be used. However, possible advantages of chemical deaeration along with pH control shouldn't be overlooked.

By keeping water alkaline (pH approximately 11) with soda ash or caustic soda, and scavenging oxygen with sulfites or the amines it's often possible to do an effective job of corrosion control.

Mr Schaub states that return-line corrosion occurs more often on lower-pressure systems. At any given temperature, solubility of oxygen in water increases with increasing pressure, see graph. Thus, higher-pressure systems are as susceptible to oxygen as those at lower pressures.

In mentioning boiler-feed pumps, the author suggests use of a well-design turbine type pump as a means of cutting suction head. Such pumps lend themselves to lower suction-head conditions, but they are likely to be more expensive than straight centrifugal designs.

H P KALLEN, *Mechanical Department Head*
Frederick R Harris, Inc, New York, N. Y.

A thrust, but no parry

Your short piece "Which way is pump thrust" (*Practical Ideas*, Jan 58, p 132) makes some seriously erroneous assertions. Whether these truly reflect the author's opinions, or are errors due to editorial changes is immaterial. The validity ascribed to anything published in a magazine with the prestige of POWER places a particular obligation on its editorial staff to avoid erroneous statements, at least without some cautioning notes.

Those who have experienced a vertically-mounted single-suction centrifugal pump's upward thrust, under starting conditions, will recognize the errors in what you've printed. The rotor rise of vertical turbine-pumps driven by hollow-shaft motors was very troublesome until the cause was recognized and corrective features adopted.

Whether the thrust of a single-suction pump is toward or away from intake flow depends on a combination of many factors, such as:

(1) The presence or lack of back wearing rings and the degree of axially corrective balance they provide.

(2) The rate of flow relative to the design point. The amount and direction of the thrust changes, as flow increases, from axial *toward* intake flow at shutoff to axial *away* from intake flow at zero developed head and maximum capacity. Exact point at which the change occurs from this factor varies with the individual design.

(3 The point at which thrust direction changes as capacity increases varies with the pump's specific speed.

(4) The thrust varies in both magnitude and in changeover point from one direction to the other, depending upon other specific design details. It varies with the velocity of the liquid in the eye and pressure distribution on the backside of the impeller. The latter, in turn, varies with several factors, primarily the back shroud's proximity to the casing backplate, in addition to any wearing rings and the liquid's axial component at discharge.

(5) On vertical-shaft pumps the rotating parts' weight—opposing thrust away from intake flow—must be considered.

If operators or service personnel were to follow the authors suggestions without question, result would be many "ruined thrust bearings and extra downtime from installing bearings backwards."

R M WATSON, *Chairman*
Department Mechanical Engineering
Syracuse University, Syracuse, N. Y.

EDITOR'S NOTE: *Dean Watson's comment relative to* POWER'S *responsibility is well put and is 100% correct. Acutely aware of this, we ceaselessly bear down for factual accuracy. In so doing we check doubtful points with recognized authorities. In view of the massive volume of technical matter handled, this obviously takes some doing. Exception is one that proves the rule.*

Maintenance and Steam Traps

. . . there's a relationship that goes far beyond trap maintenance alone

Good traps and good trapping have a greater effect on your maintenance costs than does trap maintenance itself. By that we mean that the right traps, properly selected and installed, and with the benefits of a preventive maintenance program, will save far more maintenance dollars than they will cost.

Under the pressure of spiralling maintenance costs, this thought becomes mighty important. Let's take a look at what it involves:

Proper Selection of Steam Traps

1. Be sure it's the right type of trap.

2. Be sure it's sized right and is for the correct operating pressure.

3. Be sure it's first rate in design and construction.

Proper Installation of Steam Traps

1. Install them so they are accessible for inspection and maintenance.

2. Install a test valve.

3. Use a union or unions.

4. Use a shutoff valve or valves.

5. Use a strainer ahead of the trap if dirt conditions are bad.

6. Use a by-pass only where continuity of service is imperative.

7. Standardize inlet and outlet connections.

Preventive Maintenance Program

1. Test trap regularly for proper operation. (Trap size, operating pressure and importance determine frequency.)

2. Inspect internal mechanism at least once a year.

You Get Indirect Benefits As Well

The direct benefits of the plan outlined are pretty obvious — good traps, properly selected, require less maintenance . . . testing and inspection prevents troubles that lead to maintenance.

However, this plan provides indirect benefits which reduce maintenance in other parts of the plant as well:

Good traps save steam and reduce the load (and consequently maintenance) on fuel handling and burning equipment and on ash handling equipment.

Good traps protect the system by eliminating water hammer and preventing the damage it can do.

Good traps discharge carbon dioxide before it can go into solution to form corrosive carbonic acid — less corrosion, less maintenance.

Good traps increase production to reduce the length of time equipment must operate or reduce the amount of equipment needed . . . either way maintenance is reduced.

How to Go About It (The Sales Pitch)

We admit we're prejudiced, but we don't think there is any better way to select steam traps than with the help of the 44 page Armstrong Steam Trap Book. Here in a single source is specific data on the selection and sizing of traps, how to install them for best results, and how to maintain them most economically.

The Steam Trap Book will also give you full information on the design and construction of Armstrong Inverted Bucket Steam Traps that offer these important maintenance-reducing advantages:

1. Armstrong Traps are dependable.

2. Armstrong Traps require no adjustments — go from full load to zero load automatically.

3. Armstrong Traps are self-scrubbing—ordinary dirt conditions can't hurt them.

4. Armstrong Traps have long-life parts — valve and seat are heat treated chrome steel — lever assembly and bucket are stainless steel.

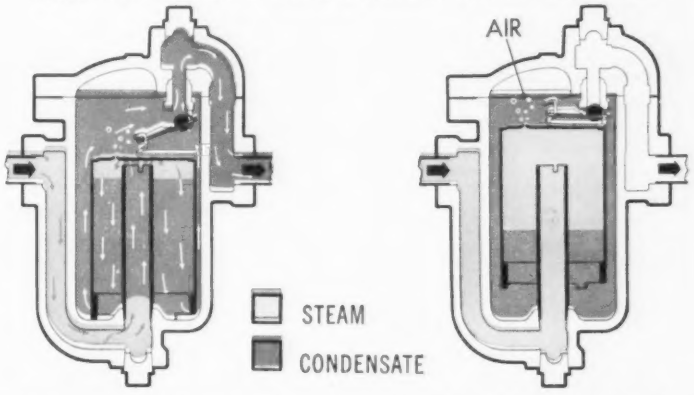
5. Armstrong Traps have water sealed valves to minimize wire drawing and erosion.

Ask for your copy of the Steam Trap Book—there is no obligation. Then test Armstrong Trapping. If you are not completely satisfied with the results, you can return the traps for a full refund of the purchase price. You can't lose much that way. Call your local Armstrong Representative or Distributor, or write

Armstrong Machine Works
8126 Maple Street
Three Rivers, Michigan

ARMSTRONG STEAM TRAPS

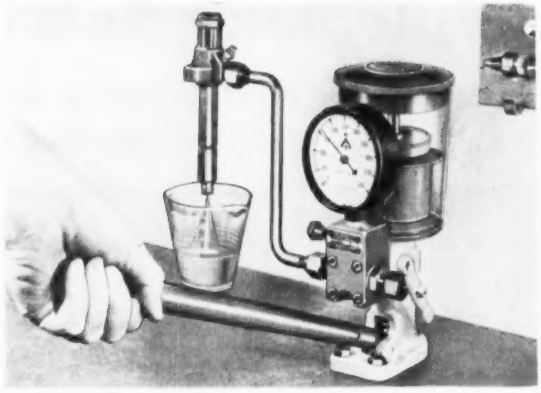
HERE'S THE STEAM TRAP DESIGN
THAT CAN REDUCE YOUR MAINTENANCE PROBLEMS



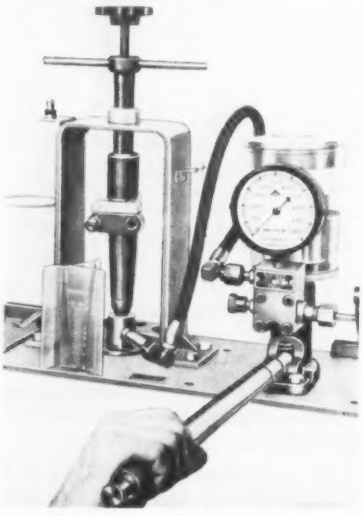
Trap open. Condensate entering trap has caused bucket to lose buoyancy. Weight of bucket times leverage pulls valve open. Air is discharged along with condensate.

Trap closed. Steam has floated inverted bucket; valve is held tightly closed by system pressure. Air entering trap passes through bucket vent and accumulates at top of trap.

VALVE OPENING PRESSURE (American Bosch nozzle). Opening pressure may be raised by increasing valve spring tension, then lowered by decreasing spring tension



SPRAY-PATTERN TEST is conducted in this photo on the American Bosch nozzle to get proper pattern spread, as in photo, below



BACKPRESSURE TEST (Cummins nozzle). In this test there should be no observable leakage of fuel at a gage reading of 2000 psi. This tightness is extremely important

SYMMETRICAL SPRAY *left* shows nozzle performing properly. Irregular spray *right* indicates need for nozzle replacement, repair

HOLDING PRESSURE TEST (GM injector). Build up to 350 psi, then observe drop. Should not exceed 200 psi in span of 50 sec for new injector; 35 sec for rebuilt

How to
test injection nozzles

Injecting fuel in a properly atomized spray of a pattern best suited for your engine is important. This quality-control function of the fuel injection system is performed by the injection nozzle. Since proper fuel injection is tops on the list for good diesel performance, preventive maintenance of injection nozzles is the most common service operation of such engines. Needed service equipment comprises a nozzle test stand and special purpose tools for the cleaning and refinishing operation.—*Courtesy, Bacharach Industrial Instrument Co.*

In JENKINS Monel-seat Bronze Gates

THE WEDGE TAKES THE WEAR - *and spares the rings*

Easy replacement of the wedge only — right on the line — restores full efficiency

THE MONEL SEAT RINGS are expanded into the body to assure a positive, leak-proof joint. Exhaustive tests in typical monel-seat gate valve services show that this permanent all-around support of the rings is essential to guard against deforming, loosening, or shifting.

THE RENEWABLE WEDGE (bronze or nickel alloy) has excellent wear resistance, but has a lower degree of hardness than the heat-treated Monel rings, which have optimum resistance to erosion and corrosion as well as abrasion. Thus, wear of the wedge leaves the rings relatively unaffected. When necessary to renew the wedge, you simply remove the valve bonnet, slip the old wedge off the stem, and slip on a new one.

GET PRACTICAL, LOW-COST RENEWABILITY in the valves you choose for the tough, punishing services that require Monel-seat gates. Compare . . . there is nothing simpler, faster, or more economical than Jenkins replaceable wedge design — and you also get the *plus* of Jenkins *extra valve* in every other feature. Jenkins Bros., 100 Park Ave., New York 17, New York.

MADE WITH BRONZE OR NICKEL ALLOY WEDGE

The bronze wedge provides lasting economy for most applications. The nickel alloy wedge provides extra resistance where rapid wear and corrosion are factors.

JENKINS BRONZE GATES WITH MONEL SEAT RINGS

200 psi	300 psi
Fig. 270-U, Bronze Wedge	Fig. 280-U, Bronze Wedge
Fig. 270-UN, Nickel Alloy Wedge	Fig. 280-UN, Nickel Alloy Wedge
Fig. 270-UL, Bronze Wedge, U.L. approved for L.P.G. Services	350 psi
	Fig. 280-UX, Bronze Wedge

JENKINS BRONZE GATES INCLUDE 40 DIFFERENT PATTERNS

125 • 150 • 200 • 300 • 350 psi SOLID WEDGE • SPLIT WEDGE
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JENKINS VALVES

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Marmy's balky crane

Sputnik sure started us thinking seriously about space—no mistake about it. Overnight, space travel seems not only probable, but highly possible. And to think that some of us can almost remember the Wright Brothers' first flight. Then, when I opened the first April issue of POWER as it rolled off the press, their was Ben Skrotzki's excellent article on "Power for space."

"Wonder what that cunning old consulting engineer thinks about all this rocket business," I asked myself the other day. "Guess I'll go up to his office and find out."

An hour later I was in the Hell's Kitchen section of Manhattan, climbing the wooden stairs that lead above O'Houlihan's Machine Shop & Engine Works. Marmaduke Surfaceblow was in; I heard his foghorn voice barking into the telephone before I got past the second stair. Standing outside his open door a few minutes later I could see the old gent was by himself. So I walked in and sat down on the old ship's settee, waiting for him to finish. Sounded like he was talking to an H B McDermid, out California way.

Soon as Marmy hung up he started studying a blueprint. He paid no attention to me.

"This Sputnik business sure is interesting, Mr Surfaceblow," I started cautiously, not wishing to annoy the cantankerous old seadog. "Do you think we'll have space ships traveling to the moon in this generation?"

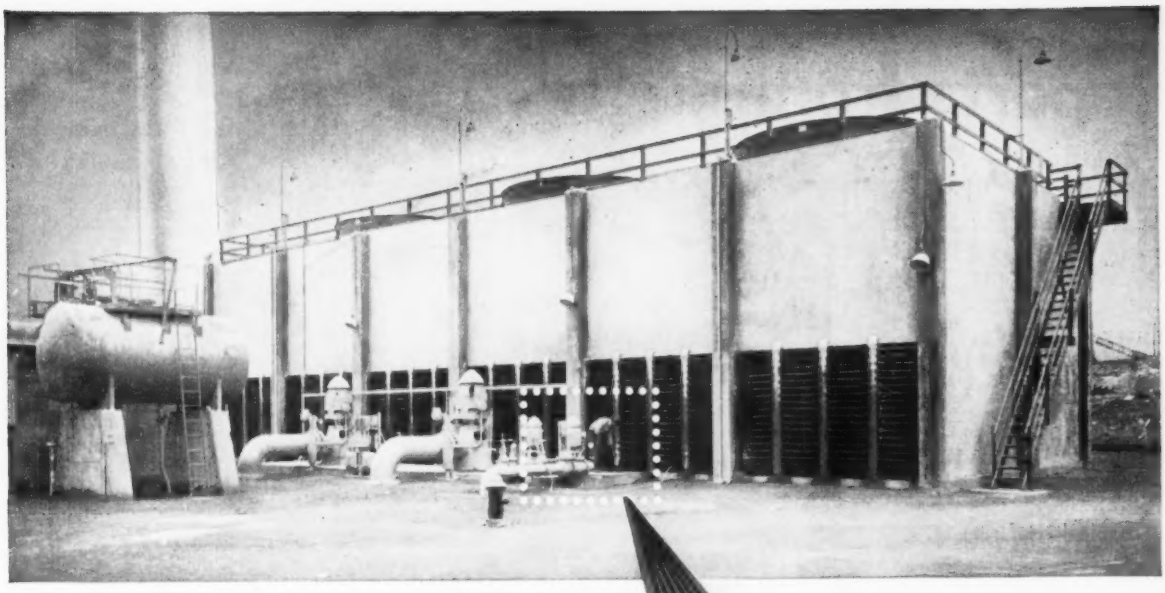
Marmy didn't bat an eyelash. Then he suddenly cleared his throat, fished a piece of rope yarn from the pocket of his checkered vest and lit it. After revving up his induced-draft blower, he blew a few smoke rings, then bellowed at the top of his voice:

"BILGEWATER on Sputnik, on rockets and on space travel. I'll tell you about the time I got a balky crane to travel and all I used was rocket-powered horse sense."

With that, Marmy characteristically leaned back in his swivel chair, hoisted his size-16 canal boats up on his tired old roll-top desk, gave his gray bowler a starboard list, and continued to blast away.

"Back in the winter of 1941, I was chief electrician at an Oklahoma oil refinery. When July rolled around I knocked (*Continued on page* 160)

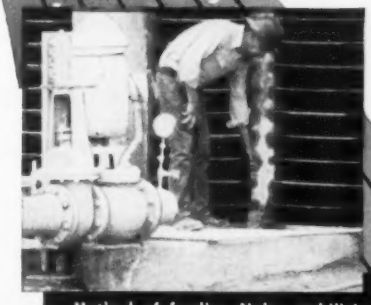
"I was up by her rails when she stalled a few minutes ago and saw everything I wanted to see," answered Marmy



Unusual Cooling Tower

gets proven *Nalco* protection

This unusual cooling tower was built for the Riverside Cement Company at Oro Grande, California. The advanced design provides for concrete exterior walls which support and enclose fan units and redwood interior cooling vanes . . . The entire "working sections" of the tower can be repaired or replaced without affecting the structural strength of the shell. Nalco System Treatment protects this cooling system against scale and corrosion — has protected it effectively since it was first put in operation over two years ago. You can get the same complete water treatment protection, promptly, from Nalco. Write for details.



Method of feeding Nalco stabilizing treatment to this system is simplicity itself. Formula is supplied in ball form. Once each shift a perforated tube suspended in the tower basin is filled with balls which slowly dissolve in the cooling water.

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WEST GERMANY: Deutsche Nalco-Chemie GmbH
SPAIN: Nalco Espanola, S.A.

Reports from the field

What's happening in power and what it means to you

Lawson Stewart joins *Power's* Staff

Latest addition to the POWER staff is Assistant Editor Lawson Stewart, who will work in the technical areas formerly handled by Howie Kallen. Mechanical Engineer Stewart will concentrate on the fields of steam generation, instrumentation, control.

Lawson has had eight years of professional experience with the Babcock and Wilcox Co. As a field service representative in their Boiler Division, his duties included inspecting new installations and all forms of troubleshooting. He's worked on the research staff of the Refractories Division. With the Boiler Division results-engineering section he did precision field testing and made special surveys.

POWER's new editor is a New York State Professional Engineer and a member of ASME. He graduated from Stevens Institute, New Jersey. After work, he goes home to a Victorian house in Bedford Hills, Westchester County, New York, and a family composed of Mrs S, three daughters and a son.

What's to come: Power industries draw a bead on the recession

Most basic guide to the overall health of business activity is the state of private investment. With competition ever stronger for harder-to-come-by dollars, one perennially surefire way to stimulate investment still holds good: give a better bargain for the money. The big companies are rolling up their sleeves and looking for more ways to do just that.

Best educated guess on our economic future is that stability, at least, is just around the corner. The McGraw-Hill Dept of Economics, checking plans for new plants and equipment, forecasts that 1958 will end 12% behind '57, but that the downgrade will level off there.

The upturn is coming, too, and may begin with increased government spending scheduled for mid-'58. One encouraging sign: the index of new machinery orders has already held stable for two months.

Meanwhile, what are individual companies doing to start the swing in industry from gloom to boom? One plan originates with the M W Kellogg people, who think they have come up with a workable version of world's number one investment stimulus: maximum yield for minimum investment.

The M W Kellogg Co has had diversified experience, handling the investment of hundreds of millions of dollars for clients 'round the world in petroleum and the petrochemical industries. Now the organization is ready to expand, offering an engineering - procurement - construction combina- (*Continued on page* 200)

Power lines

Power show will be held in New York this year Dec 1-5, in conjunction with ASME Annual Meeting.

Search is on for outstanding young electrical engineer. If you're under 36; talented and public spirited, better check with A B Zerby, Executive Secretary, Eta Kappa Nu Association, P O Drawer 447, Dillsburg, Pa. Eta Kappa Nu is looking for *you!*

Levitation for high-speed ground transportation is predicted by Ford Motor Co. Tiny air jets may suspend wheel-less cars a fraction of an inch above roadbed, for speeds up to 500 mph.

Computer users are saving money and manhours through an AIEE-sponsored system of "program" swapping. About 90 utility companies are in on the exchange.

Gas-turbine station, first for Russia, has been completed; will start up in a few months.

A 425-ft chimney will tower over fifth steam-generator unit of the St. Clair plant. Diameter will taper from 38 to 14 ft.

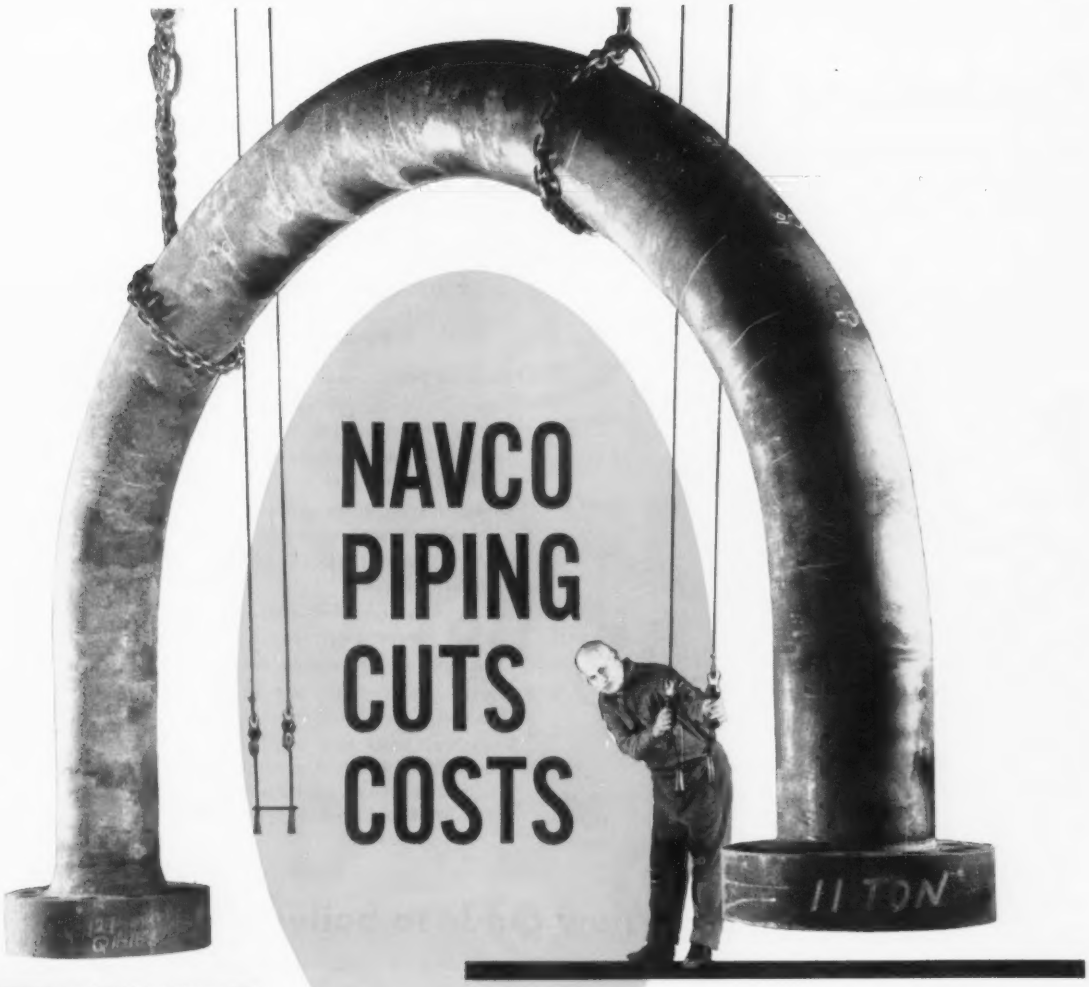
Computer installation planned by Commonwealth Edison of Chicago will measure the electricity use of 1,940,000 customers; regulate generator output.

Solar power station — world's largest—is to go up in Armenia. Mirrors will generate 20,000 tons of steam per year.

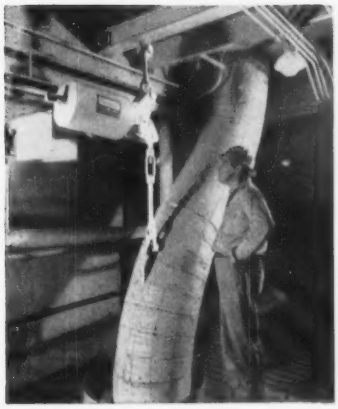
Aluminum-bronze alloy newly developed by Ampco Metal Inc is said to successfully resist stress-corrosion cracking.

Solar-heating system will heat and cool home for $450 annual bill, pay for itself in ten years in sunny climes.

For Calendar of Events see page 202



NAVCO PIPING CUTS COSTS



Rugged and easy to install, Navco's Counterpoise Pipe Hanger solves all expansion and contraction problems in piping systems. It provides a constant counterbalanced support with minimum space requirements.

For 50 years Navco's customers have received the benefits of cost-cutting efficiency and quality in Navco-fabricated and installed piping systems.

Here are a few of the many ways Navco can help you save money:

- Thoroughly analyzing the costs of various types of available pipe, particularly alloy or heavy wall materials, and then taking into consideration the installation costs of each.
- Design changes to achieve the most practical and economical fabrication method.
- Workmanship and final cleaning that result in lowest possible maintenance.
- Erection under the supervision of permanent key personnel trained in all phases of piping.

Navco's fine craftsmanship, constant research, alert engineering and quality control can cut your piping costs. Call Navco for your next piping job.

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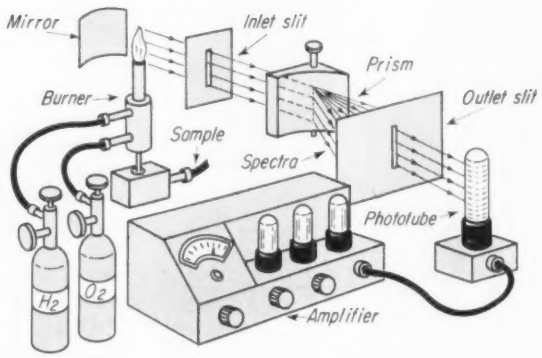
Technical briefs

Latest engineering developments for busy power men

11 papers for you on:
WATER TREATMENT
SYSTEM ENGINEERING
ATOMIC POWER



IN PHOTOMETER, flame excites atoms of all elements in sample; atoms emit rays by which they can be identified, measured

Flame photometry vs conductivity

Test data	*Part 1*	*Part 2*	*Part 3*
Evaporator load, lb per hr	20,000	32,000	38,000
Sodium in steam, by recording flame photometer, ppm	0.0004	0.0004	0.0006
Solids in steam, calculated from sodium content, ppm	0.0012	0.0012	0.0018
Conductivity of condensed steam, degassed (Hagan), micromhos	0.77	0.55	0.63
Solids in steam, calculated from conductivity, ppm	0.44	0.31	0.36
Sodium in concentrated sample, (100:1 concentration), ppm	0.041	0.052	0.075
Solids in 10 gal evap. sample, mgs	0.5	0.5	0.5
Solids in steam that would be equivalent to above, ppm	0.013	0.013	0.013
Solids that would have been in evap. 10 gal sample if solids as calculated from conductivity data had been correct, mgs	16.7	11.8	13.7

Flame photometry: a new guide to boiler-water purity

The development and operation of an ultra-sensitive recording flame photometer. *By W A Crandall and W Nacovsky, Consolidated Edison Co of New York, Inc*

Recent investigations have shown that conductivity measurements as an index of steam and water purity are often unreliable under 5 micromhos and invalid under 1 micromho. Other studies have shown that in certain cases such techniques as sodium flame photometry and the use of radioactive tracers produce results that can be correlated with the performance of modern high-pressure boilers, evaporators, etc.

The authors describe development of a successful automatic sodium-flame photometer analyzer and recorder. They discuss means of eliminating interferences such as "dark current" and noise, and present information on improved burner, photomultiplier and electronic circuits for the unit.

A novel means of rapid field calibration by means of light emitted by dry flame is a feature of the instrument. The authors give plant applications showing the instrument's adaptability where more conventional test methods are unsatisfactory.

They conclude that the continuous recording sodium-flame photometer is a successful operating instrument. Its sensitivity is in the fractional parts-per-billion range. Its ultimate lower limit has not been explored because it is so far below any of the waters encountered to date as to be of no practical significance.

The established capability of the instrument makes it suitable for monitoring condensate at nuclear plants. Other uses are developing, some of which are mentioned in the paper.

Only one experimental model has been built to date. The authors hope the instrument will be commercially built and in the process become simpler and more compact while retaining all of the good features it now possesses. *APC paper, no number.*

Comparison of mixed-bed and four-bed demineralizers. *By F B Wink, Niagara Mohawk Power Corp, and D Miller, The Permutit Co*

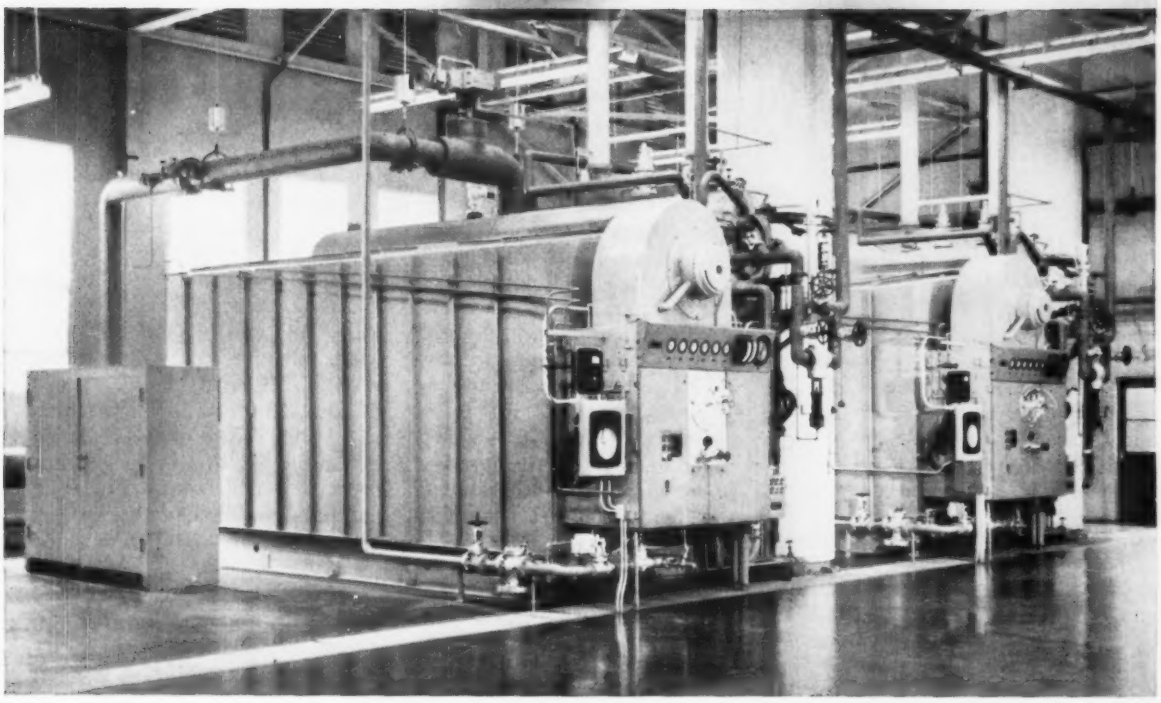
The experience with operation of mixed-bed and four-bed demineralizers at Huntley Station has led to these conclusions:

(1) Both systems can produce water of a quality suitable for make-up to high-pressure boilers, but the four-bed demineralizer has given more consistent operation, in this case where some organic contaminants apparently still remain despite the pretreatment used.

(2) Although organic contaminants apparently are present, they do not seem to affect the operation of the four-bed demineralizer as rapidly as the mixed-bed unit.

(3) Overall operating costs are less for the four-bed system, but the full extent of the difference cannot be determined as yet since the resin in this system has shown no deterioration. (*Continued on page* 150)

PACKAGED STEAM
by Foster Wheeler
at BOEING DEVELOPMENT CENTER



Two 34,000 lb/hr Packaged Steam Generators supply heating and process load at aircraft and missile research center

In the boiler room at Boeing Aircraft Company's new development center in Seattle, Washington, the two Foster Wheeler AG-134 Packaged Steam Generators shown above provide ample capacity for both present and future loads.

Each unit has a guaranteed rating of 34,000 lb/hr at 250 lb design pressure and 150 lb working pressure with oil firing. When firing natural gas, the output is 32,000 lb/hr.

Shipped completely assembled from Foster Wheeler's Dansville, N. Y. plant, they were installed on simple slab foundations. Each unit is equipped with semi-automatic combustion controls and a 44-inch self-supporting stack. The 36-inch steam drum includes a baffled steam collector, piping for feedwater distribution, continuous and surface blowoff. Staggered boiler bank tubes and closely spaced waterwall tubes contribute to high efficiency while large furnace volume provides conservative rates of heat liberation.

FW Packaged Steam Generators are now available in capacities from 10,000 to more than 60,000 pounds per hour. For complete information, write to *Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N. Y.*

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(4) The operators have found the four-bed unit somewhat more dependable in operation, and easier to maintain. *APC paper, no number*

Demineralizer treating hot-lime zeolite effluent replaces evaporators in Ford's River Rouge plant. *By A K Sukumar, Ford Motor Co, and S B Applebaum, Cochrane Corp*

This paper briefly discusses some of the past changes in No. 1 power house as well as in the water-treatment plant. The latest advance was installation of a large automatic demineralizer (800,000 lb per hr capacity). This demineralizer is unique in a number of respects:

(1) An existing hot-lime zeolite plant served as a pretreatment plant to clarify and presoften a contaminated surface supply. The hot effluent is cooled from 220 to 95F by large heat exchangers ahead of the demineralizer to protect the anion resin of the demineralizer. This heat exchange is effected with no heat loss from the system, by using the mill-water makeup to the hot-lime softener as the cooling medium.

(2) The two-bed demineralizer has each of the three pairs of cation and anion units in combination double-deck shells, with cation compartment above and anion compartment below. This made the installation unusually compact and saved valuable floor space.

The demineralizer is described in detail, and the operating results since start-up in 1957 are given. *APC paper, no number*

The effect of dissolved oxygen on weak- and strong-base anion exchangers. *By I M Abrams, B N Dickinson and M Roberts, Chemical Process Co*

Many studies have been made on the causes for anion resin instability. There are now two recognized causes for resin deterioration: organic fouling and chemical attack. Fouling is generally associated with strong-base resins and has been attributed to naturally occuring organic substances usually found in surface waters. Chemical attack may occur either on the matrix of the resin or on the amine groups attached to the resin. This attack may be either hydrolytic or oxidative.

This paper is concerned with oxidation attack.

There seems to be no doubt that strong oxidizing agents such as chromic acid, chlorine or hypochlorites can cause resin degradation. These agents may cause discoloration, swelling, attrition and capacity loss. But in many instances, resin deterioration is observed without the presence of such obvious oxidizing agents and without evidence of organic fouling agents being present.

The effect of dissolved oxygen on strong-base resin performance has been a subject of diverse opinions. The present paper is intended to shed some new light on this apparent difference of opinion with the hope that the information may aid in prolonging the life of anion exchange resins. *APC paper, no number.*

System engineering

The criterion of economic choice. *By P H Jeynes and L Van Nimwegen, Public Service Electric and Gas Co*

The authors point out the advantages of distinguishing between (1) selecting the economic choice and (2) capital budgeting. They discuss difficulties that arise when analysts try to solve problems in the first category by applying techniques appropriate for the second. The authors claim that the economic choice is the alternative having minimum present worth of revenue requirements; that is, the revenues needed to earn a rate of return acceptable to investors after paying all expenses.

The paper describes the solution to problems in engineering economy in two steps: (1) determining which alternative is most economic and by how much, and (2) selecting the most desirable plan, in the light of (1) plus other factors not reducible to dollars.

This approach is equally appropriate for regulated utilities or non-regulated industry. The paper also discusses practical applications of this technique to long-range estimates as encountered in system planning, as well as means for anticipating the effect of future changes in price levels. *AIEE paper, No. 58-113*

Power systems for small plants served at above 15 KV. *By L H Gruetzmacher and D B Armstrong, General Electric Co*

A method is developed in this paper for determining when one-step voltage transformation (directly to the utilization level of 600 volts or below) or two-step transformation (from incoming to an intermediate voltage of 2.4 to 13.8 kv, with power distribution to secondary unit substations at this voltage) should be used for small industrial plants. This gives the power-system designer a tool, based on economics, for quickly knowing which type of distribution system to consider.

Specific plant configuration determines, to a great extent, the type of distribution system that should be used. Beginning with close, compact plant-load areas, at load densities approximating 15 va per sq ft, the two types of distribution systems are about equal in cost at 4000 to 5000 kva load. Variations in plant configuration, a lower average load density, or locating the incoming power termination further from the basic load areas, lowers the plant kva load size at which the double-transformation distribution system becomes more favorable. *AIEE paper, No. CP-58-262*

Generator unit size study for the Dayton Power & Light Co. *By W J Pitcher, Dayton Power & Light Co; L K Kirchmayer, A G Mellor and H O Simmons Jr, General Electric Co*

The Dayton Power & Light Co has just completed a joint investigation with the General Electric Co to determine the relative costs of expanding system generating facilities with various unit-size expansion patterns.

(*Continued on page* 178)

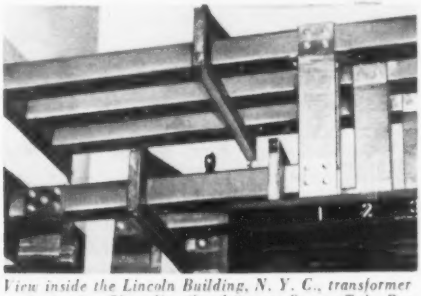
Directions for ordering papers on page 182

BEST WAY TO FEED A SKYSCRAPER

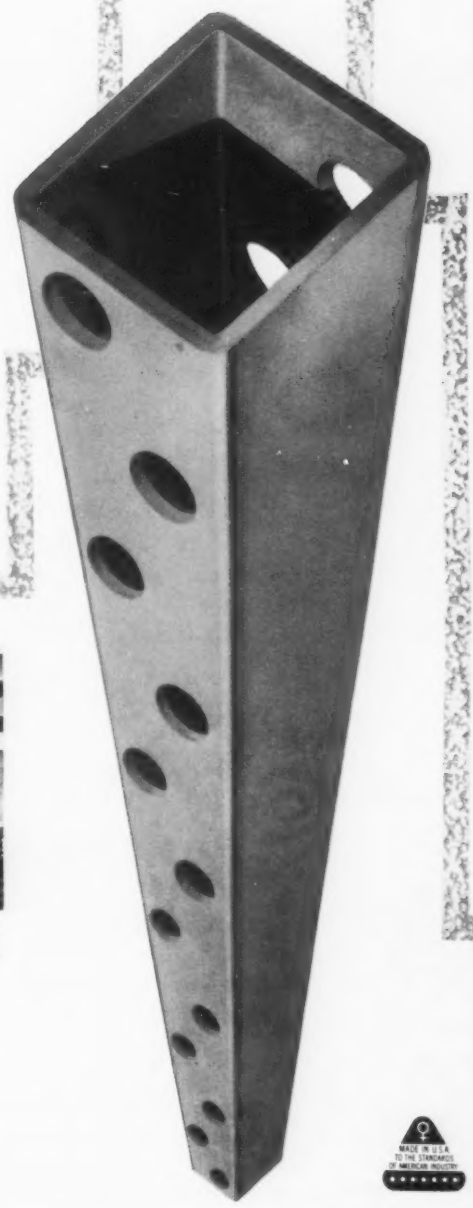
New York's Lincoln Building gets all its power needs through Chase® ventilated square copper tube bus conductors

In the heart of mid-town Manhattan, the 53-story Lincoln Building is supplied all of its electrical power through a distribution system built around Chase Ventilated Square Copper Tube Bus Conductors. In the building's transformer vault, 6 high-rated transformers and four services, each capable of handling 3,500 amps, make a total of 14,000 amperes of current available to meet the building's needs.

Whether you measure your power requirement in thousands of KVA or in lesser units, you can best handle it with Chase bus conductor. Chase Square Copper Tube Bus is available in unventilated from 1″ square x ⅛″ thick and ventilated from 2″ square x ⅛″ thick to 11″ square x ½″ thick. Current capacity runs as high as 14,200 amps at a 50°C. rise above 40°C. ambient for ventilated bus. Ask your nearest Chase representative for specific recommendations on handling your exact current supply problems with Chase Square Copper Tube Bus Conductor. You can reach him locally, or at Waterbury 20, Connecticut.



View inside the Lincoln Building, N. Y. C., transformer vault showing Chase Ventilated Square Copper Tube Bus Conductor. Installation designed and made by Consolidated Edison Company of New York.



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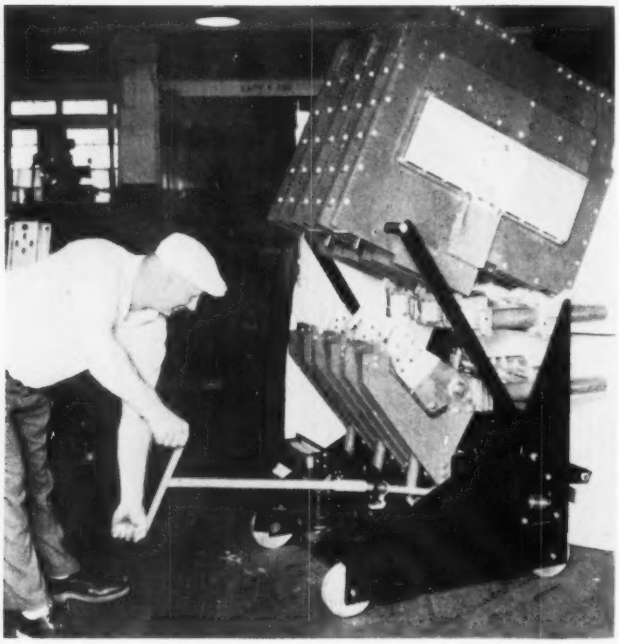


Breaker interrupts 1000 mva

601 • This metalclad switchgear unit features a 13.8-kv magnetic-air circuit breaker of 1000-mva interrupting capacity. The metalclad breaker is designed for use in protecting distribution circuits in large city substations.

Assembly has 35% greater interrupting capacity than the next lower rating of its type, but has the same height and width and is only 4-in. deeper, according to the manufacturer. Horizontal drawout is said to simplify replacement or maintenance on the breaker.

Ceramic arc chutes, which are used for the main interrupter elements, feature high dielectric strength, low moisture absorption and high resistance to heat shock.—*Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.*

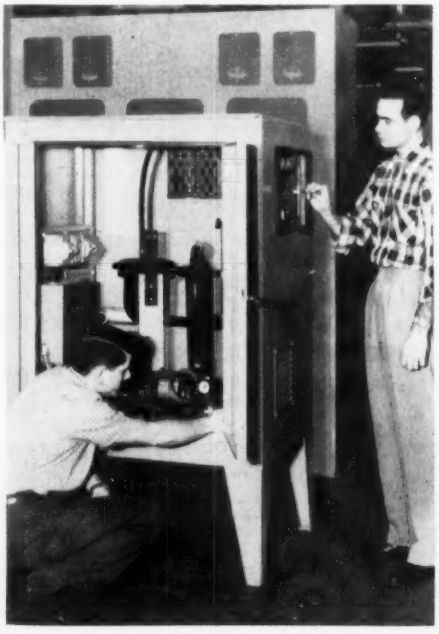
For more data on these items, use post cards on page 157. Identify your request with item number

Analyzer takes exit gases at 3200 F

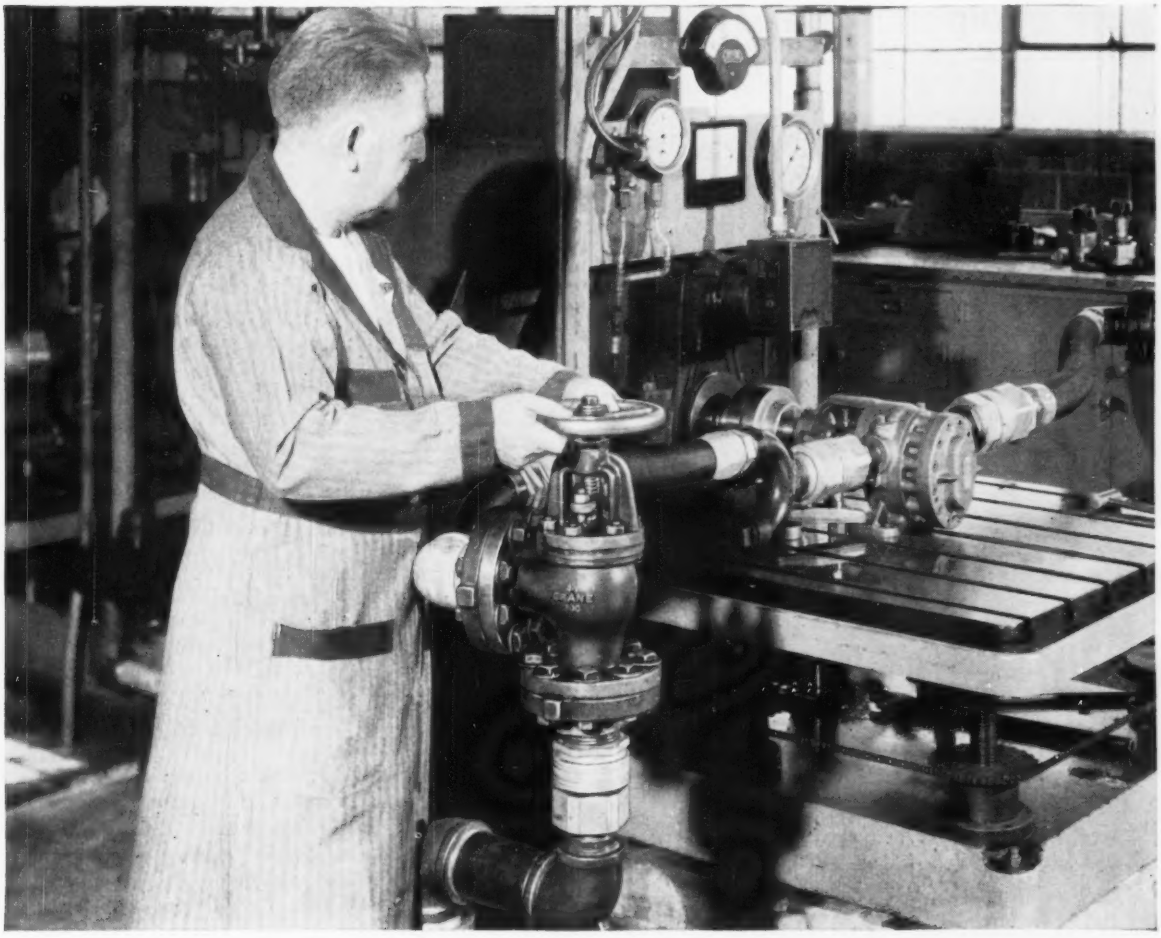
602 • Gas-analysis system continuously samples, cools, washes and analyzes exit gases at temperatures up to 3200 F, according to manufacturer. System tests the gases for oxygen and combustibles.

This setup can examine gases from all types of combustion equipment. Completely enclosed in a single compact cabinet, it contains a gas pump, washer, separator trap, electrical switchgear and analyzer. The cabinet is 66x41x30 in.; weighs 1240 lb. Transfer valves may be included for multiple-point sampling.

The system can be installed indoors or out. Sampling tubes are water-washed, water-cooled type for gases to 3200 F, water-spray type for dirty gases at a maximum temperature of 1200 F, and dry type for fairly clean gases at temperatures up to 800 F (black iron) or 1200 F (stainless steel).—*Bailey Meter Co, 1050 Ivanhoe Rd, Cleveland 10, Ohio.*



Roper Hydraulics, Inc. Experiences CRANE Quality



Uses CRANE valve on severe throttling for 23 years—without repairs

Twenty-three years ago, Roper Hydraulics, Inc., Rockford, Ill., installed this Crane 2½-inch, 300-pound bronze plug disc angle valve for throttling service on a 300- to 400-pound pump test line. Since then, testing has been done at pressures up to 1000 pounds without valve failure.

Altogether, this Crane valve has been operated intermittently on an average of 30 hours weekly for 23 years! Only recently was it necessary to replace some of its working parts. Here is demonstrated proof that Crane quality is really the durable kind purchasing agents seek . . . the dependable kind that engineers and plant operating people want.

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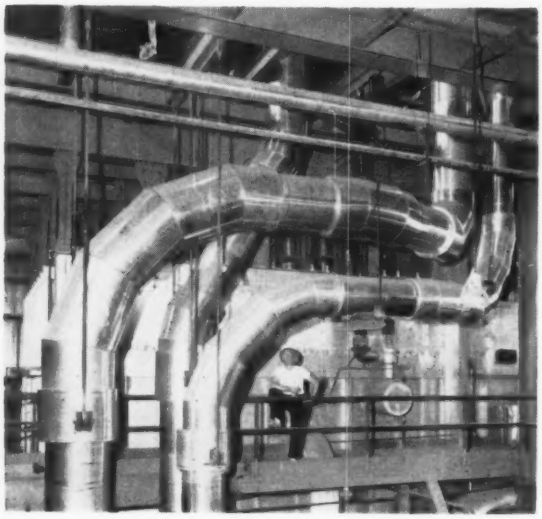


Prefab insulation is "done with mirrors"

603 • Lightweight all-metal reflective insulation is said to control operating temperatures and minimize heat losses on the "thermos-bottle" principle. The insulation can be constructed to handle industrial temperatures from –400 to +2000 F, according to maker.

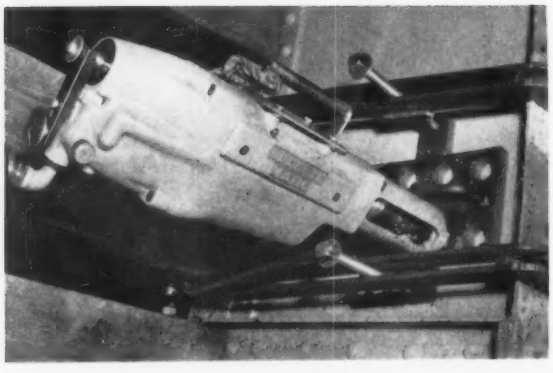
Massless insulation is made up of air spaces partitioned by reflective metal sheets. It comes in prefabricated units for pipes, fittings, vessels, equipment, boiler casings and ducts. Aluminum alloys are used for a temperature range of –100 to +1000 F, stainless steels for extreme temperature applications.

Insulation comes with an integral outer case of heavy-gage metal. Because of all-metal construction, it is said to be nonabsorbent, sanitary, easily cleaned. It can be removed and replaced safely, and isn't affected by vibration or thermal shock.—*Mirror Insulation Co, Inc, 201 S Main St, Lambertville, N. J.*

Tool ends danger from overdriven fasteners

604 • Power-actuated fastening tool is said to stop an overdriven fastener in its tracks before it leaves the tool, eliminating the danger of projecting a fastener into free flight through a thin work surface. A new assembly with interceptor jaws prevents passage of an overpowered fastener, or one that encounters a soft spot in the work surface. When fastener is stopped, operator pulls the tool off the work and is ready for another fastening. This stoppage can cause no damage to the tool, according to manufacturer.

Unit is operated by pulling a trigger. Fasteners can be seated in a wide variety of nonbrittle materials, including as much as one inch of steel. A worker can set up to 150 fasteners an hour, maker states.—*Ramset Fastenings System, 12121 Berea Rd, Cleveland 11, Ohio.*



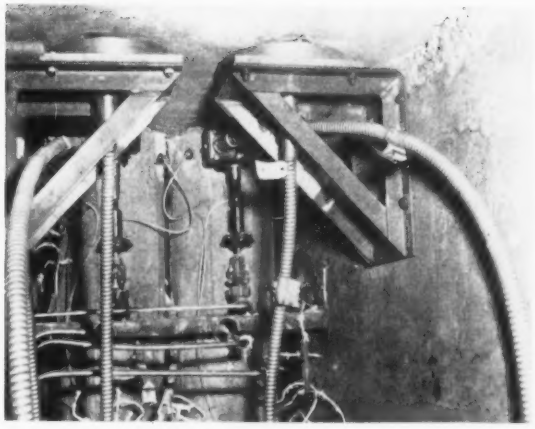
Mechanical-feed drill features portability

605 • Machine-tool precision, portable-tool convenience are combined in this automatic drill, maker claims. Once started, the tool goes through a complete drilling cycle, including retraction and stopping, automatically. The unit is designed for applications where drilling is done at several points on a large workpiece, but it may also be used with permanent fixtures, where work is brought to the tool.

Rated capacity is 1½ in. in steel. Maximum stroke is six inches. Mechanical feed is said to insure forward progress as long as drill rotates.—*Buckeye Tools Corp, 5051 Springboro Pike, Dayton, Ohio.*

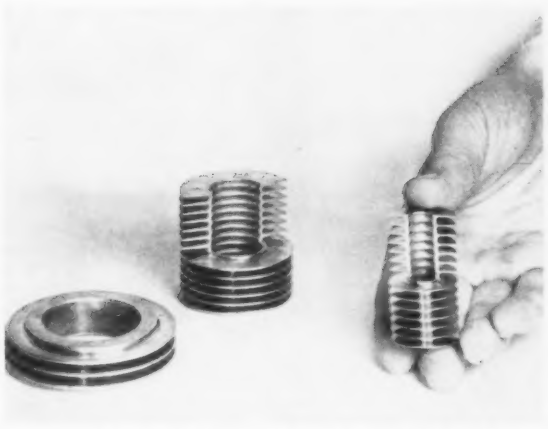
For more data on these items, use the post cards on page 157. Identify your request with item number

Begins on page 152



Reactor controls are gamma-ray proof

606 • Manual remote controls for nuclear-reactor valves are used in contaminated areas. Flexible-shaft controls are said to cope with gamma rays, which travel in a straight line until stopped. Controls function through walls in irregular curves, so that rays leave their direct path and dissipate in the surrounding insulation. Control assembly includes flexible shafts in ½- to 1⅝-in. sizes; asbestos packing; a nonorganic lube.—*Stow Mfg Co, 181 Shear St, Binghamton, N. Y.*



Atom-plant tubing now has integral fins

607 • Integrally finned tubing comes in low carbon steel and magnesium-beryllium alloy for use in gas-cooled nuclear power plants. Fins, which are literally rolled up from the tube's walls, increase heat-exchanger efficiency by exposing up to 1000% more surface, according to manufacturer. Tubing comes in 1/16- to ¼-in. wall thickness in low carbon steel; 1/25 to ¼-in. in Magnox.—*Wolverine Tube Div of Calumet & Hecla, Inc, 17200 Southfield Rd, Allen Park, Mich.*

Scaler converted to counter

608 • Unit is said to convert any scaler into a proportional counter for precision radioactivity measurement in prepared samples. Unit has a built-in amplifier-discriminator. It plugs into any 110-v circuit, connects to the input of any scaler, and detects alpha and beta activities of all energies. Unit takes samples up to 2¼-in. dia x 7/16 in.—*Nuclear Measurements Corp, 2460 N Arlington Ave, Indianapolis 18, Ind.*

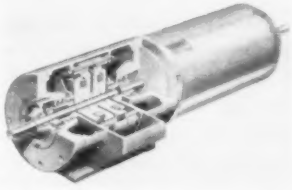
Titanium fittings available for reactor use

609 • A complete line of welding fittings and flanges of commercially pure grades of titanium to match every schedule and size of titanium piping currently made is now being offered.

Titanium, available until recently only for defense use, weighs 56% as much as stainless steel. The metal has a high strength-to-weight ratio at temperatures up to 850 F, and has extreme corrosion resistance. Good resistance to abrasion makes it suitable for use in piping radioactive materials.

Corrosion resistance makes titanium piping and fittings suitable for use with nitric acid, wet chlorine gas, solutions of chlorine, chlorinated organic compounds, inorganic chloride solutions. It is not corroded by salt water or marine atmosphere.—*Tube Turns Div of National Cylinder Gas Co, 222 E Broadway, Louisville, Ky.*

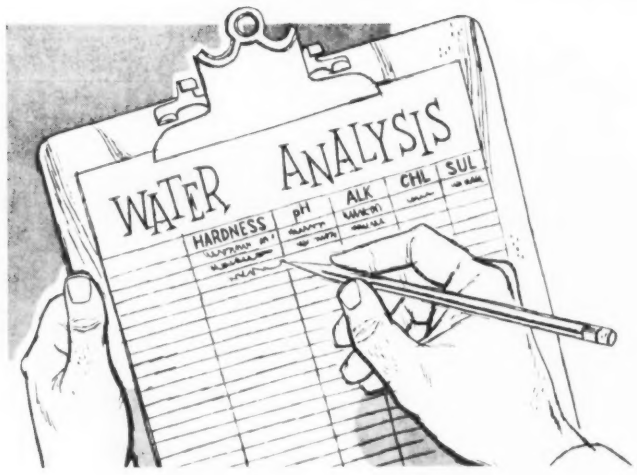
Don't miss this item . . .



Variable-speed drive . . . p 168

. . . or other new product information appearing on the following pages

Capacitor equipment . . . p 168
Immersible motor . . . . . p 170
Neoprene jacketing . . . . p 170
Bellows coupling . . . . . p 170
Rotary pump . . . . . p 172
Dielectric test set . . . . . p 172



George Edwards

submits the case for treating water, not the boiler

Fortunately for me, I'm one of those people who can be a chowhound and never have to worry about putting on weight. And a guy who loves to eat can pick a flock of choice spots in this land of ours.

One of these is Reading, Pa. Those of you who like Pennsylvania Dutch cooking know what I mean. I had lunch there a couple of weeks ago with Bill Firman, Stu Distelhorst and John Cafferty and left the table swearing that I couldn't look a deep-dish apple pie in the face for a year.

Bill and Stu build packaged firetube boilers and John—a visiting fireman like myself—heads up a boiler service and repair outfit in Cedarhurst, L. I. During lunch our talk naturally centered around packaged boilers in general and finally zeroed in on how slipshod maintenance will beat the brains out of any boiler. In John's business, he rubs shoulders with a lot of mistreated boilers and he's got some pretty strong views on the subject. Particularly where negligence results in damage from scale deposits and corrosion.

"If I was a boiler manufacturer," he said, "on each boiler I sold I'd put a sign that read: 'This boiler does *not* need internal treatment.'"

We raised our eyebrows at this. Everyone knows that all boilers need a good feedwater treatment and we said as much to John.

"You guys are talking about treating the *water*," he retorted, "and that's my point. Does a man run an electric motor without lubrication or under prolonged overload? No, because he knows it'll be his fault if he damages the motor by this sort of carelessness. But for some strange reason the same guy will blame his boiler troubles on everything but his own lack of horse sense.

"Suppose we told him point blank: 'Listen mister, we're giving you a boiler that's engineered to the hilt to do the job you want. How you treat it is up to you. If you use lousy water that'll plate its insides with scale and let oxygen get in its corrosive licks, then don't come crying to us that your tubes are leaking like sieves or your furnace is in a bad state of collapse.'

"I'm in favor," John concluded, "of pulling him up short. Let him know that using proper feedwater treatment, not gimmicks, is his baby and nobody else's. Maybe a little 'shock treatment' is what these people need."

Whether or not John's shock treatment would have any effect is a moot question. It's an interesting idea, isn't it? You'll have to admit that he has a number of reasons for feeling the way he does. They equal the number of boilers damaged every year both from negligence and a tendency to treat effects rather than eliminate causes.

However, I think the boiler manufacturers and reputable feedwater-treatment people are gradually winning the battle. They'll keep on providing the user with all the engineering advice he needs, in the hope that he'll take advantage of it. Not being magicians, they can't *make* him think. They can do no more than lead a horse to water.

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AIR CONDITIONING, HEATING, VENTILATION

1 **Redesigned line** of heating, ventilating units is described in 48-p catalog 8927. Separate sections cover coils, fan section and accessories. Includes tables of capacities, air friction, filler data and installation drawings. American Blower Div of American-Standard, Detroit 32, Mich.

2 **Heating, ventilating** and air-conditioning units are subject of 12-p bulletin 701. Featured section covers automatic filters. Illustrations include 17 tables and charts of performances, dimensional data. American Air Filter Co, Inc, Louisville 8, Ky.

3 **Industrial heaters** are discussed in 4-p bulletin. Includes specs, a cutaway drawing. Lennox Industries Inc, Des Moines, Iowa.

4 **Tubular-centrifugal** fans for air conditioning, ventilation and processes are covered in 16-p catalog. Curves, specs are given for direct and V-belt drive. Dryer Electric Corp, 164-166 Wallabout St, Brooklyn 6, N. Y.

ELECTRICAL EQUIPMENT

5 **Magnetic components** are subject of 24-p bulletin. Transformers, chokes, saturable reactors and magnetic amplifiers are discussed and illustrated. Varo Mfg Co, Inc, 2201 Walnut St, Garland, Texas.

6 **Synchronous generators,** engine-driven low-speed types, are subject of 8-p bulletin GEA-5299B. Uses are illustrated and described. General Electric Co, Schenectady 5, N. Y.

7 **Motor-application guide** is a 12-p booklet. Designed to ease selection, it contains application charts, details on line of 1/20- to 400-hp motors. Century Electric Co, 18th & Pine Sts, St Louis 3, Mo.

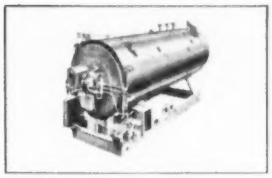
8 **Plug-in busway,** 225-1000 amp, is discussed in 24-p booklet GEA-6173. Lists features, applications, includes illustrations and dimensional drawings. General Electric Co, Plainville, Conn.

9 **Stationary battery** is described in 12-p catalog GB-1833. Tabulated specs include amp-hr capacity, discharge rates, dimensions. Gould-National Batteries, Inc, Trenton 7, N. J.

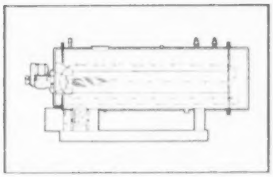
10 **Secondary unit substations,** from simple radial systems to secondary selective systems, are covered in 20-p bulletin 18B6285C. Photos illustrate installations. Allis-Chalmers Mfg Co, Milwaukee 1, Wis.

11 **Circuit breakers,** current-limiting models for use on low-voltage systems, are discussed in 20-p booklet 5043-A. (*Continued on page* 184)

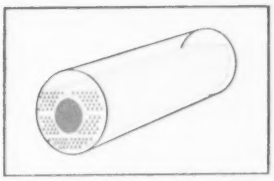
NOW . . . all these "BIG BOILER" features in a compact, economical package . . .



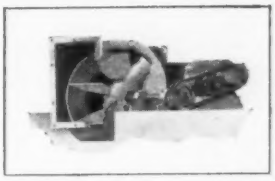
A complete package including boiler burner, draft equipment, controls and all interconnecting piping and wiring. Completely assembled and factory fire-tested.



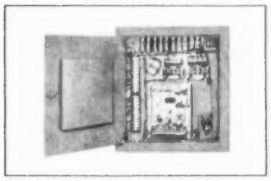
4-pass down-draft design, promotes rapid water circulation. Decreasing tube volume in successive passes provides high combustion gas velocities and maximum heat transfer.



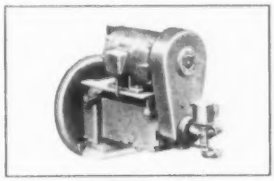
5 sq. ft. of heating surface per b.h.p. Units reach conservative ratings with ease. Guaranteed thermal efficiency 80%. Stack temperatures not exceeding 125° above steam or water.



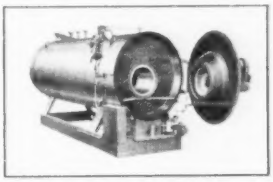
Induced draft operating at relatively slow speed results in unusual quiet plus safety from danger of forcing gases out into boiler room. Negative furnace pressure also protects refractory.



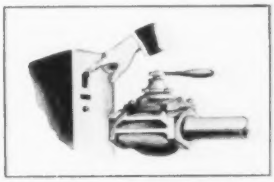
Fully automatic operation firing oil, gas or both. Firing rate adjusts to demand, never overfiring wastefully, but handling sudden increases without lag. Variety of controls available.



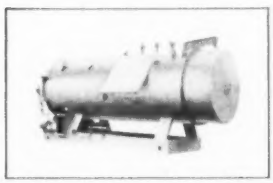
Superior Rotary Burners on all sizes firing No. 4, 5 and 6 oil. Most dependable type of equipment ever devised for burning heavy oils. Burners require minimum supervision, and no lubrication.



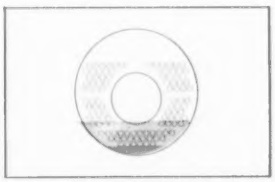
Hinged front and hinged or davited rear door on all units. Doors may be opened simply without removing refractory and are simply and effectively sealed with standard asbestos rope.



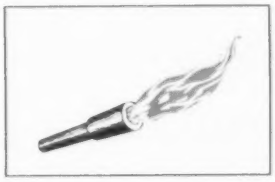
Instantaneous fuel changeover. Units equipped for oil and gas firing may be changed from one fuel to another quickly and simply by operating only a switch and a valve.



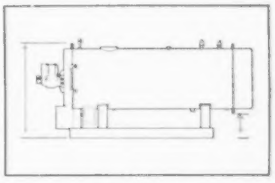
Completely insulated and jacketed. Even the bottom of the boiler shell is covered with 2" insulation. No uninsulated areas for heat loss and unnecessary heating of the boiler room.



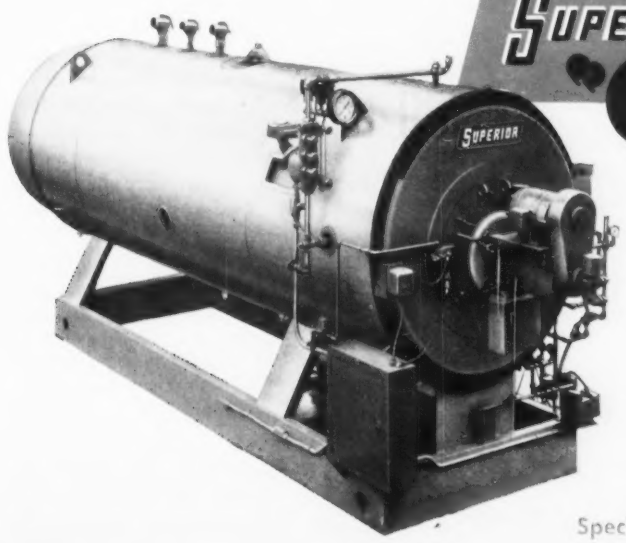
Down-draft design places furnace high in shell, safely away from danger zone . . . completely eliminates bagging and blistering resulting from mud build-up in bottom of boiler.



Constant gas pilot remains lit at all times, prevents accumulation of gas in the furnace which could result from even an almost undetectable leak in the gas valve.



Low total height but with clearance from floor allows ample room under the shell for inspection, maintenance and installation of piping. The COMPACT is practical as well as compact.



SUPERIOR "COMPACT"

Here at last is a boiler which combines all of the most desirable features of big boiler design with an unusual degree of compactness. Ideal for installations where space is limited, it also provides an economical answer both from the standpoint of purchase and installation costs for any application having steam requirements of from 20 to 200 B.H.P.

Pressures to 250 psi, or hot water units also available. Write today for Bulletin 1000C.

SUPERIOR COMBUSTION INDUSTRIES INC.
TIMES TOWER, TIMES SQUARE, NEW YORK 36, N.Y.

Specialists in PACKAGED BOILERS . . . exclusively

REVOLUTIONARY NEW SEAL

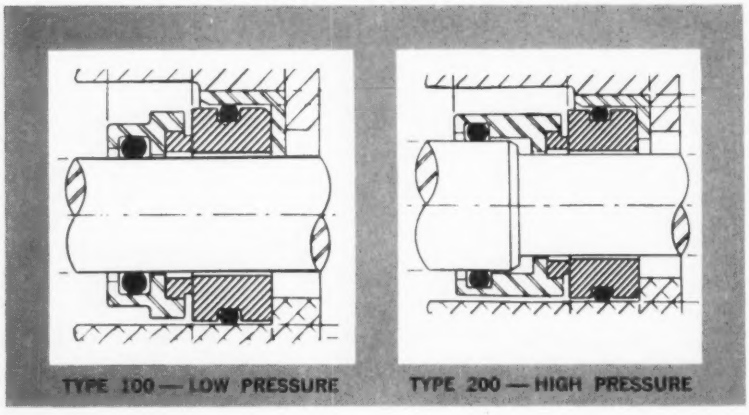
MAGNETIC
Chesterton
SEAL

ELIMINATES:

Springs
Set Screws
Spring Stops

Requires only 2 parts and two O-rings

First basic improvement in Mechanical Seals in 35 years



SIMPLE TO INSTALL — Self positioning — Does not require dismantling of pump. Magnetic attraction of sealing and mating rings eliminates use of springs. Up to 18 parts eliminated. Sealing contacts always positive and even. Seal is so thin it will fit in shallowest of boxes.

Complete brochure gladly furnished on request.

A. W. CHESTERTON CO.
6 ASHLAND ST., EVERETT 49, MASS.

America's Oldest Manufacturer of Mechanical Packings

Marmaduke

Continued from page 144

off for a few weeks' vacation and drove up to my Ozark home town of Mildew, Missouri. After a few days of hunting, fishing and general hell raising, I shoved off for St. Louis before heading back to Oklahoma.

"One evening, while flushing the barnacles out of my piping system at the Packet Bar & Grill on the river front, I ran into Jack Younger, a local steel-mill electrician. Jack told me about a headache at his mill that had the entire engineering department suffering.

"According to his story, they had two new cranes installed on the same runway. One crane worked fine and had been accepted by the mill soon as it had been tested. But the other one would stall at times for no good reason. She was so unpredictable that the mill refused to pay for it.

"Both cranes were designed to handle limber pieces of steel without distorting them. To do that, each crane had two winches carrying two sets of hooks. And both winches ran on tracks laid on bridges running the length of the runways. In that way they could cover all the areas in the storage warehouse where steel shapes were stored.

"Jack told me that a trouble shooter from the crane company had been pulling his hair out for three days looking for the bugs. He had tried every trick he knew, but no soap. He even checked each contact a number of times, but still the crane would stop suddenly. Then, just as suddenly, she'd start perking as if run by a horde of playful ghosts.

"According to Jack, the trouble shooter put in a long distance call to his Pittsburgh headquarters the day before. He wanted an assistant to help him check out all the circuits. But his boss at the home office said he couldn't send anyone for another week. In the meantime, the steel company's works manager was blowing his top because the crane was slowing down some rush orders.

"After listening to his story I told my electrician friend that I'd like to visit his plant the next morning before shoving off for Oklahoma. Jack said he'd be happy to introduce me to the crane company's expert because he was sure he'd welcome any suggestions. (*Continued on page* 162)

Master Key...

TO POWER'S LOW COST FUTURE

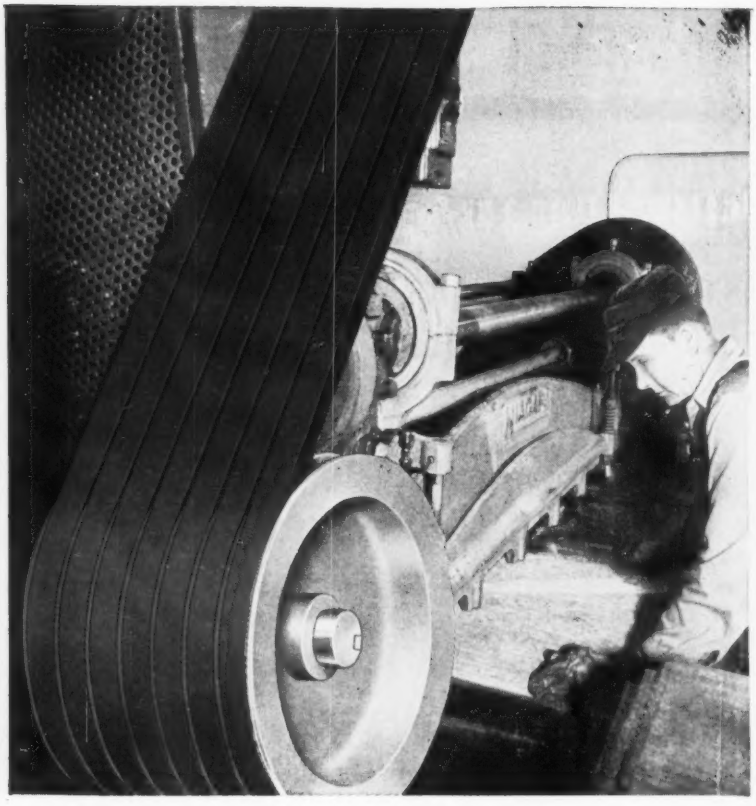
BITUMINOUS COALS FOR EVERY PURPOSE

• Bituminous coal contributes to plant operating profits by its *productivity* and *stability*. Virtually limitless supply, plus most modern mining methods, gears production to *any volume demand.*

Accessibility and increasingly efficient burning equipment mean economical, constant-cost for today and tomorrow.

B&O

Ask our man! BALTIMORE & OHIO RAILROAD, BALTIMORE 1, MD., Phone: LExington 9-0400



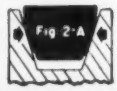
Industry's No. 1 choice... the V-Belt with concave sides

Here's the reason:
the concave sides of Gates V-Belts *insure far longer belt life.*

Make this simple test. Bend a Gates V-Belt with concave sides (Fig. 1) as if it were going around a sheave. Feel how the sides *fill out* . . . become perfectly straight (Fig. 1-A). Note how this belt makes full contact with the sides of a sheave . . . grips the sheave evenly, distributing wear uniformly across the sides of the belt. Uniform wear lengthens belt life — keeps costs down.

Now make the same test with a straight-sided belt (Fig. 2). Feel how the sides bulge out, (Fig. 2-A) concentrating wear at the points shown by arrows. Uneven wear shortens belt life; increases belt costs.

Because Gates V-Belts with concave sides are so universally preferred, they are also the *most widely available*. There are Gates distributor stocks in industrial centers throughout the world.



The Gates Rubber Company
Denver, Colorado
World's Largest Maker of V-Belts

TPA 312

Gates

Gates VULCO ROPE Drives

Marmaduke

Continued from page 160

"Next morning I met Jack at the plant gate. He took me to the warehouse to see the new cranes. The expert wasn't around, but both cranes seemed to be operating OK. While waiting, I climbed up where I could see the feed wires that fed juice to the motor's collector wheels. The crane seemed to be OK, so I started down. Then, just as the balky crane started with a heavy load for the second time, it groaned to a halt. The operator stuck his head out of the cab window and began cursing and yelling. He was letting everyone know they'd better get another operator if they couldn't give him a crane that worked. That's when the works manager and the expert walked into the building. I navigated over to them and Jack introduced me.

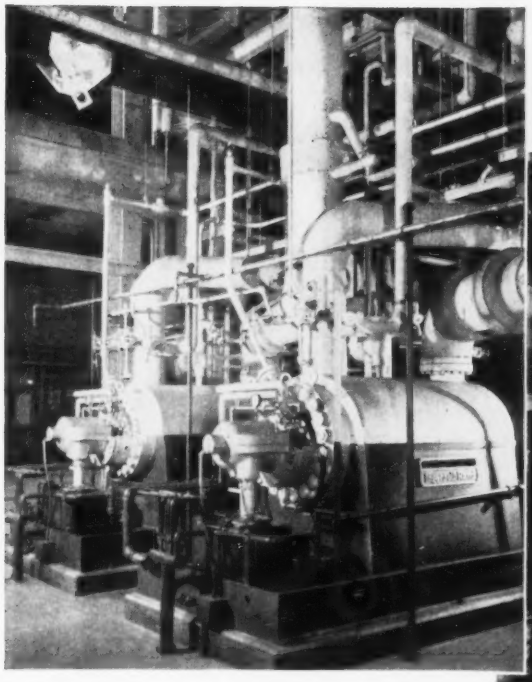
"After sizing me up, the expert explained, 'Only thing I can think of is to check out her circuits. And, since the home office can't send me a man, I'll be happy to have you work with me. Damned if I see how it can be a circuit though,' he added with a hopeless look on his pan. 'Yet, I've tried everything else I can think of.'

"'What good is *this* guy?' asked the works manager of the expert, jerking a thumb at me. 'Hell,' if you can't find the trouble, you don't expect the first guy who walks in here off the street to do any good.'

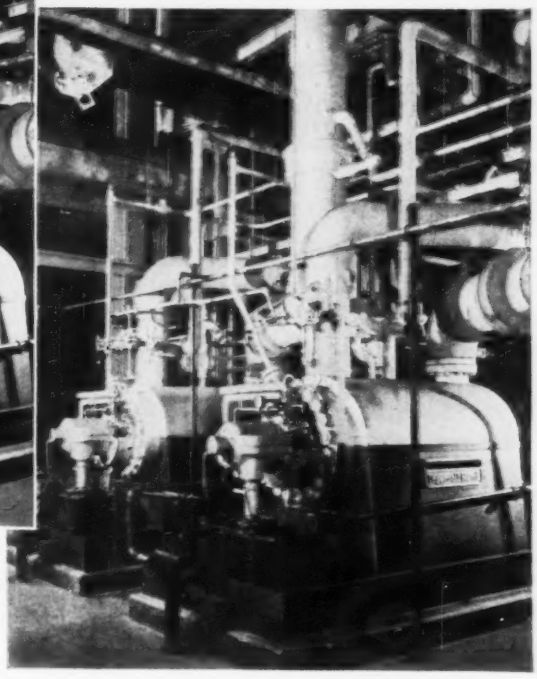
"'I didn't come here as anyone's helper,' I answered, getting up a head of steam. 'I came to *tell* you the trouble—but on a consulting basis—and for a fee. And I'll tell you exactly what's wrong in one minute. But, now that you've crossed my bow, it'll cost you twice what I had in mind. That's two hundred American dollars.'

"'What?' barked the works manager. 'You mean to tell us that you can put your finger on the trouble and you've just seen this crane for the first time?'

"'I was up by her rails when she stalled a few minutes ago and saw everything I wanted to see,' I answered. 'Besides, I'm not just a guy off the street. I've been shipmates with all kinds of plant equipment in every part of the globe. And I stuck around St. Louis here instead of driving down to Oklahoma today only because I never pass up a



Two Ingersoll-Rand 11-stage CHTA boiler feed pumps now serving Unit No. 1 at Milliken Station.



Duplicate CHTA 11-stage boiler feed pumps are on order for Unit No. 2, now under construction.

2 MORE IR BOILER FEED PUMPS

for Unit No. 2 at MILLIKEN STATION

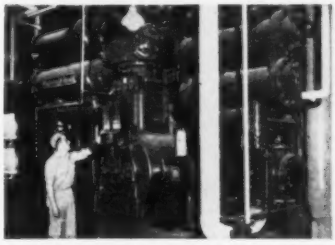
TO SERVE rapidly growing loads in the Finger Lakes area, New York State Electric & Gas Corporation is *doubling* the capacity of Milliken Station which went on line in Sept., 1955. Unit No. 2, now under construction, will be a duplicate of Unit No. 1 – consisting of a 135,000 kw turbo-generator with a capability of more than 150,000 kw.

The boiler feed pumps are also duplicates – two Ingersoll-Rand 11-stage CHTA units, each rated 1165 gpm at 5530 ft total head and driven at 3570 rpm by a 2000 hp motor. The I-R air compressors shown at the right for Unit No. 1 are also being duplicated for Unit No. 2.

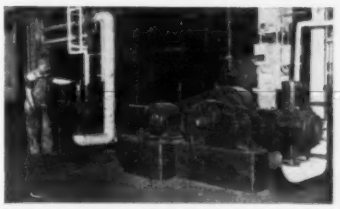
Repeat orders like this are tangible *proof* of complete satisfaction with the units already in service. In leading power plants from coast to coast, I-R high-pressure boiler feed pumps with the exclusive unit-type rotor assembly are making impressive records of trouble-free performance – and resulting in repeat orders again and again.

For the best solution to your boiler feed pump problems, just get in touch with your nearest I-R representative.

Other I-R Equipment at Milliken Station



One of two Ingersoll-Rand Class TVH soot-blowing compressors serving Unit No. 1 at Milliken Station.



Two Ingersoll-Rand Class ES-NL compressors with non-lubricated cylinders, supplying oil-free instrument air for Unit No. 1. Another ES unit with standard oil-lubricated cylinder provides general plant air.

Ingersoll-Rand

11 Broadway, New York 4, N. Y.

10-682

COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

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Capacity
⅛" to 2"

This RIDGID Spiral Reamer is fun to use, the smooth-as-butter way it turns into the metal—pipe, conduit box outlets . . . making holes in sheet metal. Using is believing—most for your money . . . buy this super-reamer at your Supply House!

. . . or that other whizz for both hand and power reaming, RIDGID LonGrip, with five straight flutes that assure clean work, extra easy control.

The Ridge Tool Company • Elyria, Ohio, U.S.A.

Marmaduke

continued from page 162

trouble-shooting challenge. So it'll cost you $200 for me to tell you what's wrong. Then you can correct the trouble in five minutes.'

"That had both of them stopped. The expert scratched his head and blinked a few times. My electrician friend looked at me with opened mouth. The works manager started blowing off steam, but all he did was sputter.

" 'OK!' he finally said to the expert, 'it's your headache. Your firm won't get paid until that crane works. I'll call your boss and tell him we'll charge this lost production against your bill if that damn crane isn't fixed. Maybe then he'll agree to pay this man his $200. Hell, I need that crane today—not next year.'

"Five minutes later, after a hurried call to Pittsburgh, he and the expert returned from the office. They told me to get busy. By that time we had an audience of a dozen guys from the front office who'd heard the scuttlebutt about some miracle about to happen.

" 'This I've got to see,' barked the works manager. 'Here you've been trying to straighten out this crane for days. And this stranger takes one look and says he's got the answer. OK, Mr Edison,' he said smiling from ear to ear, 'let's hear you speak your piece.'

" 'It's simple enough,' I answered. 'I looked at the wires that feed juice to the motors of that crane's collector rings. They seemed to be installed OK, with both ends at the same height above the bridge rails. From that I knew that the contact wheels should make contact at the same pressure against the feed wires at all positions of the rings as they move back and forth across the bridge.

" 'But watching that crane come to a halt sparked a question in my mind. Suppose the collector rings aren't at the same height on the double trolley? Then the trolley with the higher collector wheels would lift the feed wires off the collector wheels that are set too low. That would open the circuits on the lower set of collector wheels and kill the motors on that crane's trolley. So how about the height of those collector wheels, Mr Expert? Are they equal?'

"But he just stared at me like a

No Excessive Heating

New Rectifier Cooling System Prevents Heat Build-up and Damage

when ac Power Fails

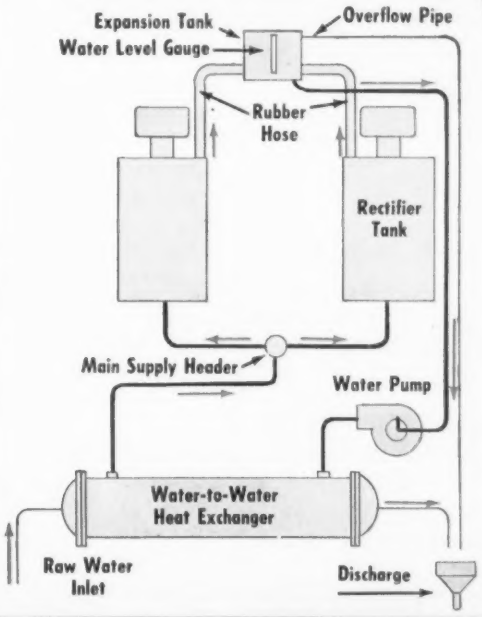
A SAFER, more effective cooling system in the Allis-Chalmers rectifier continues to circulate water *even when an ac power failure stops the water pump.* Heat and steam are dissipated before they can develop to the danger point.

The new system features an expansion tank that extends the full length of the rectifier frame with short vertical connections from each tube. With warm water continuing to flow freely upward, a thermo-siphoning action draws cooler water into the tubes. Build-up of excessive temperatures is prevented. Steam pockets are kept from forming. Subsequent water loss from the recirculating cooling system is minimized.

Successful operation in hundreds of installations is your assurance of the complete reliability of Allis-Chalmers mercury arc rectifiers. Contact your nearby A-C office or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

How the System Works

Water is normally pumped through the water-to-water heat exchanger to the main supply header from where it circulates through rectifier tubes picking up heat. Hot water flows up through the short connections to expansion tank and back down to suction side of water pump.



ALLIS-CHALMERS Mercury Arc Rectifiers

Factory-packaged units cut installation time and costs. Sealed tube rectifiers are supplied in completely enclosed or open types. Here is a typical, completely enclosed, 1000-kw, 250-volt rectifier for steel mill service.

ALLIS-CHALMERS

A-5425

CONSECO's Field Department is equipped and thoroughly qualified by over 30 years' experience to repair, re-tube or rebuild any type of tubular equipment, of any manufacture. Extensive facilities and personnel handle emergency assignments on the job or in our own shops. A CONSECO re-built unit is usually a better product than the original equipment because it benefits, during repairs, from our familiarity with all types of tubular equipment and of features that help to achieve longer, trouble-free, more efficient operation.

Full maintenance and spare parts service available. Emergency service at any hour, day, night, holiday; anywhere on the continent. Just call Maintenance Department.

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When equipment is repaired or rebuilt thoughtfully, as CONSECO does, changes in design, care of construction and ease of maintenance are developed that improve the original product. The application of these improvements to NEW EQUIPMENT DESIGNED BY CONSECO brings genuine profits to users of CONSECO products.

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For more data consult Chemical Engineering Catalog pages 559-562

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COMPLETE BULLETINS SENT ON REQUEST

Marmaduke

Continued from page 164

stunned mackerel, without saying a word. Suddenly he came to life, scooted up to the crane bridge and started measuring the height of the two sets of trolley collector wheels. In a minute he yelled down to us. "'You win, Mr Surfaceblow, one collector wheel is just a bit higher than the other.'

"Soon he was adjusting one collector wheel so it had the same pressure against the feed wires as the other. Then he started testing the crane. After fifteen minutes of running her back and forth, doing all kinds of maneuvers, that crane hadn't stalled once.

"The works manager offered me a cigar and asked me to have lunch with him. But, when I said I'd have to shove off for Oklahoma, he asked me to his office where he had a check made out for me.

"'I'll take it off the crane company's bill,' he said, shaking my hand. 'And if you ever run out of a job, come see me.'"

With that, Marmy dropped his feet to the floor, lit up his rope yarn and started puffing furiously away as he started checking the blueprints before him. I shoved off quietly for my office to record his experience for posterity. STEVE ELONKA

Marmy's Mailbox

MARMY ON TV?

Why aren't the Marmy stories adapted for TV? After all the silly cowboy shows and soap operas, seems to me a robust character like Marmy with his unusual engineering solutions would be great. Why doesn't some engineering sponsor wake up and give the public a real treat?

FRANCIS SMITH, *Chicago, Ill.*

YES, TV FOR MARMY

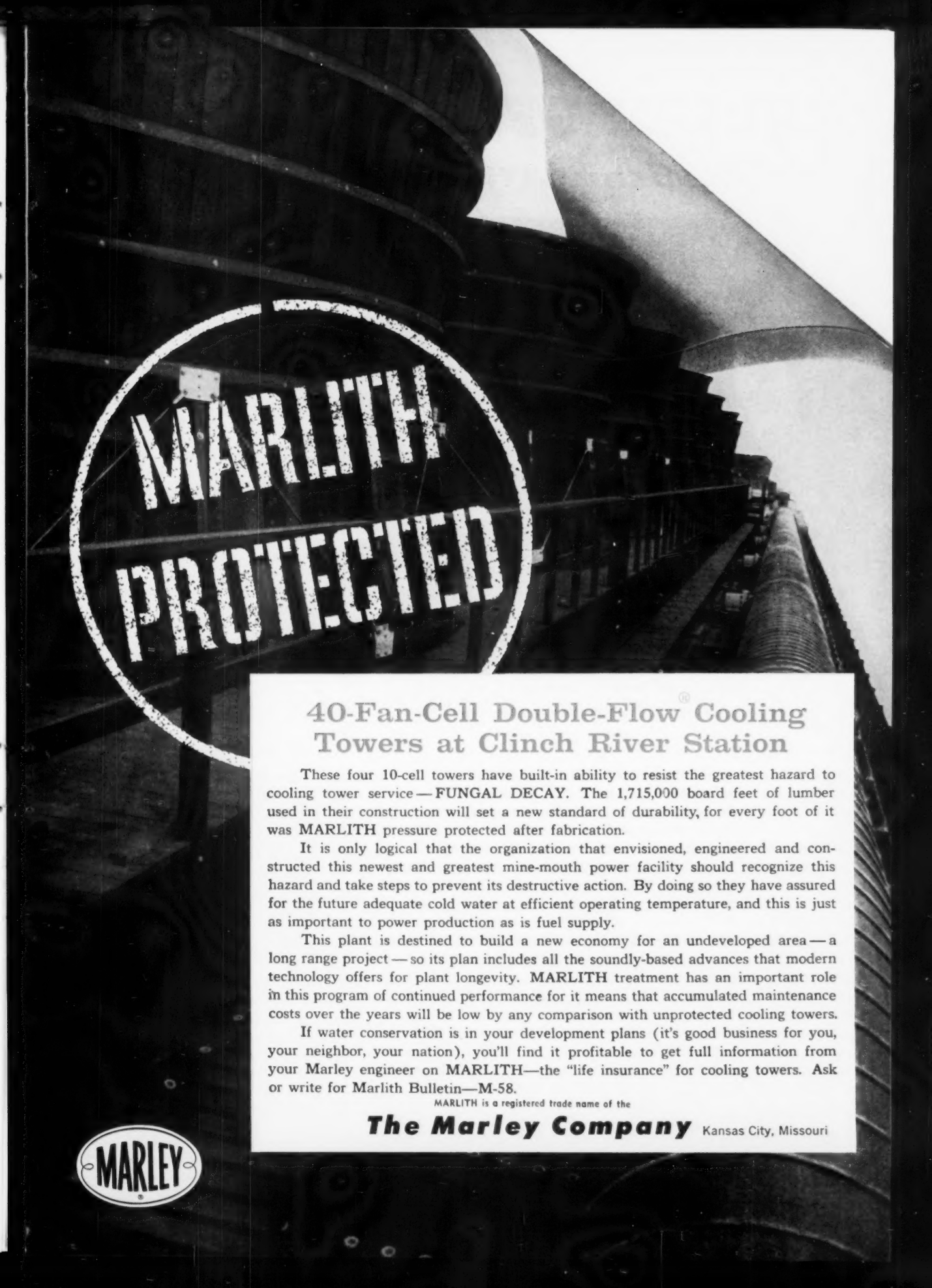
It would be wonderful to have that crusty old bugger, Marmy, appear on TV. After reading his stories in POWER all these years, I'm sure he'd be a TV sensation.

F FLINT, *Toronto, Ontario*

MARMY IS FIRST

First article I read in POWER is Marmaduke because I have used some of his tricks and found them practical. Next comes "George Edwards."

E TURRENTINE, *Dallas, Texas*



40-Fan-Cell Double-Flow® Cooling Towers at Clinch River Station

These four 10-cell towers have built-in ability to resist the greatest hazard to cooling tower service — FUNGAL DECAY. The 1,715,000 board feet of lumber used in their construction will set a new standard of durability, for every foot of it was MARLITH pressure protected after fabrication.

It is only logical that the organization that envisioned, engineered and constructed this newest and greatest mine-mouth power facility should recognize this hazard and take steps to prevent its destructive action. By doing so they have assured for the future adequate cold water at efficient operating temperature, and this is just as important to power production as is fuel supply.

This plant is destined to build a new economy for an undeveloped area — a long range project — so its plan includes all the soundly-based advances that modern technology offers for plant longevity. MARLITH treatment has an important role in this program of continued performance for it means that accumulated maintenance costs over the years will be low by any comparison with unprotected cooling towers.

If water conservation is in your development plans (it's good business for you, your neighbor, your nation), you'll find it profitable to get full information from your Marley engineer on MARLITH—the "life insurance" for cooling towers. Ask or write for Marlith Bulletin—M-58.

MARLITH is a registered trade name of the

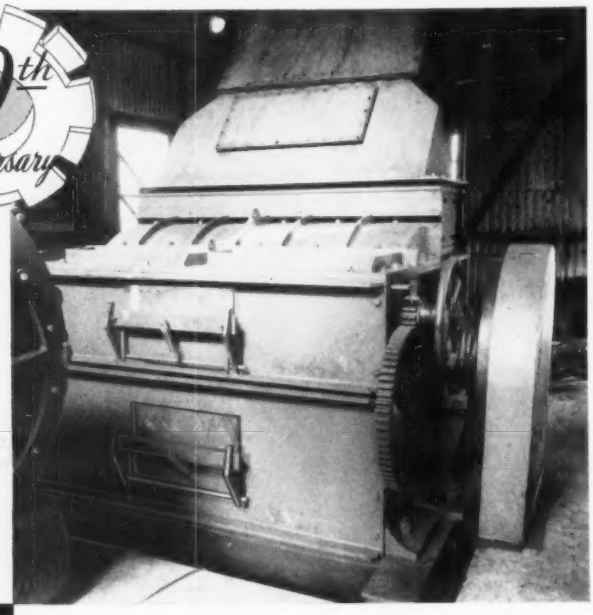
The Marley Company Kansas City, Missouri

MARLEY®

CRUSHING FACTS

from American PULVERIZER CO.

50th Anniversary



USER REPORTS

"We've reduced 2,521,000 tons of 2" N & S coal to a ¾" product. Crusher has given satisfactory service. Rings and screens have been renewed only once."

Replacement parts on this American AC-7C Rolling Ring Crusher after crushing 2½ million tons of coal have cost only $0.0016 per ton (1/6th of a cent).

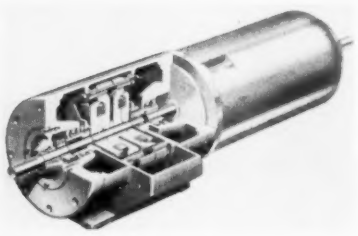
There's good reason for performance records like this. The American originated rolling shredder ring efficiently splits coal instead of crushing it. Coal spends less time in the crusher; therefore, there is less attrition in the crushing chamber and less wear on the screens. Further, the rings are reversible for double wear. In addition, the effectiveness of the crushing elements permit slower operation speeds.

Our engineers will analyze your reduction problem. No obligation to you.

American PULVERIZER COMPANY
ORIGINATORS AND MANUFACTURERS OF RING CRUSHERS AND PULVERIZERS
1349 MACKLIND AVE. ST. LOUIS 10, MO.

Equipment news

Begins on page 152



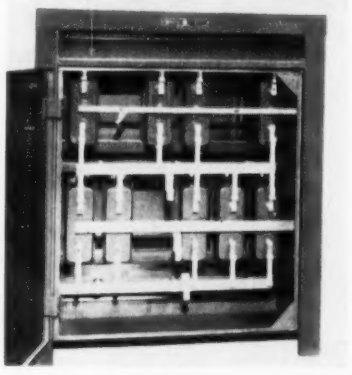
Variable-speed drive

610 • Infinitely variable-speed drive is said to use constant-speed motors, feature heat-dissipating design. Built on the eddy-current principle, the unit comes in four dripproof models in six sizes.

Models include a separate controlled-slip coupling, various combinations to serve as variable-speed gearmotor, variable-speed motor or special unit for integral mounting of speed reducers. Dc power supplies are not required, maker states.

The drive is said to operate stalled at full torque without overheating when driven by 1750-rpm motors of up to 100 hp.—*Cone-Drive Gears Div, Michigan Tool Co, 7171 E McNichols Rd, Detroit 12, Mich.*

For more details on these items, use post cards p 157. Identify your request with item number.

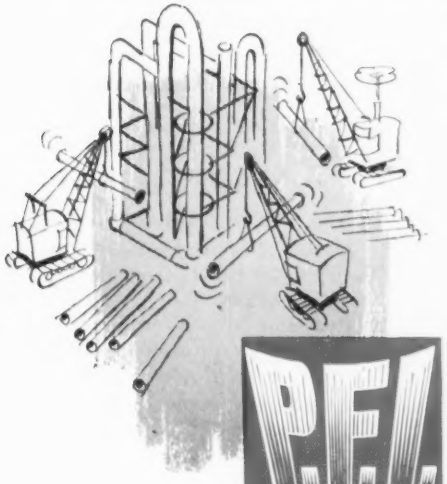


Small capacitor equipment

611 • Low-voltage capacitor equipment for outdoor industrial applications is available in ratings from 60 to 180 kvars, 230 v, and 80 to 240 kvars, 460 and 575 v, 60 cycles. Individually fused capacitors are assembled in weatherproof housing.

Removable plate at base of equipment provides for incoming-line connections. Line terminals are clamp-

"QUICK . . . HAND ME MY P.F.I. Standards"



The gent in the helicopter would really be "up-in-the-air" if he couldn't find his P.F.I. Standards.

Experience has taught him that the use of P.F.I. Standards saves time and money in the design, particularly in the fabrication and erection of high pressure — high temperature piping.

These standards, compiled by the Engineering Standards and Metallurgical Committees, are daily proving their worth from the design-drawing board stage through to final application of prefabricated piping in many types of industries.

Write for all ten P.F.I. Standards or indicate in the coupon below which ones could be helpful in your particular field.

P.F.I.
THE PIPE FABRICATION INSTITUTE

1 Machining Backing Rings for Butt Welds
2 Dimensioning Welded Assemblies
3 Linear Tolerances, Bending Radii
4 Shop Hydrostatic Testing
5 Cleaning Fabricated Piping
6 Built-up Weld Metal Bosses
7 Welded Nozzles—Spacing
8 Preheat-Postheat Before, After Welding
9 Arc-Welding Dissimilar Ferritic Steels
10 Stress Relieving Practices

THE PIPE FABRICATION INSTITUTE

Devoted to the Technical and Economic Problems in Piping

ONE GATEWAY CENTER, PITTSBURGH 22, PA.

Please send me the P.F.I. Standards indicated

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Name_____

Company_____

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MX trailer inspection unit—a complete test and inspection shop on two wheels; can be set down with ease in any spot in your plant.

To be sure--

Call in **MAGNAFLUX**

NATION-WIDE COMMERCIAL INSPECTION SERVICE

Preventive maintenance in power plants is simplified when you make Magnaflux Field Inspection Service a regular part of your scheduled maintenance plan. Magnaflux field engineers, thoroughly experienced, use numerous exacting tests to spot future trouble quickly and reliably, saving your own people many hours of inspection time.

Magnaflux testing insures that equipment restored to service after overhaul is *fit for service*—a common-sense approach to reliable operation.

This inspection means less risk of unplanned shutdowns. Fatigue cracks and corrosion often don't show up under other test methods. Magnaflux methods detect even the tiniest flaws. Complete, detailed reports, including photographs, records and drawings where necessary, are furnished after each plant call. This guides future maintenance operations, and helps spot potential troubles during scheduled outages.

Magnaflux Commercial Inspection Plants in 16 cities make an experienced "pool" of trained field engineers available to you on a 24-hour basis. When you need this service, your Magnaflux team is as close as your telephone. This nationwide service gives you all the benefits of a specialized, fully trained crew on a stand-by basis—*but on your payroll only while they are working for you.* When you schedule your next overhaul, also schedule the Magnaflux Inspection Service to give any degree of inspection you may require. Also, we have a folder on "Power Plant Maintenance". Write, if you'd like a copy.

MX crews are equipped for all magnetic and fluorescent tests, penetrant tests, eddy current, X-ray, gamma-ray, ultrasonic, electrostatic and brittle-coating stress inspection.

Write for full details now—
OR CALL ANY OF THE COMMERCIAL INSPECTION PLANTS SHOWN BELOW.

MAGNAFLUX CORPORATION

7324 West Lawrence Avenue, Chicago 31, Illinois

HALLMARK OF QUALITY IN TEST SYSTEMS

Mineola, L. I., N. Y. Pioneer 7-3220	Philadelphia, 33 BAldwin 3-5500	Detroit 11 TRinity 3-4343	Dallas 35 FLeetwood 2-2626
Newark 4, N. J. HUmbolt 3-1235	Pittsburgh 36 TUxedo 2-3448	Indianapolis 18 LIberty 7-1303	Houston 21 WAlnut 3-9169
E. Hartford, Conn. BUtler 9-2737	Cleveland 15 HEnderson 2-0727	Chicago 39 EVerglade 4-1561	Oakland 8 OLympic 8-0201
Bridgeport, Conn. EDison 6-2113	Cincinnati 23 MUlberry 1-6436	Los Angeles 22 RAymond 3-8961	Van Nuys STate 5-8640

Equipment news

Begins on page 152

type connectors, require only a wrench for connecting cables, according to manufacturer. — *General Electric Co, Schenectady 5, N. Y.*

Immersible motor

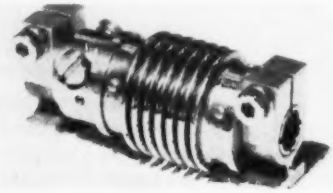
612 • Designed for submerged operation, unit can be close-coupled to agitators or pumps in sewage sumps, chemicals, water and abrasive industrial oils, according to manufacturer. Motor shaft is directly attached to impeller.

Unit comes in ratings of $\frac{3}{4}$ to 40 hp, single-phase and polyphase.—*The Louis Allis Co, Dept P, 427 E Stewart St, Milwaukee 1, Wis.*

For more details on these items, use post cards p 157. Identify your request with item number.

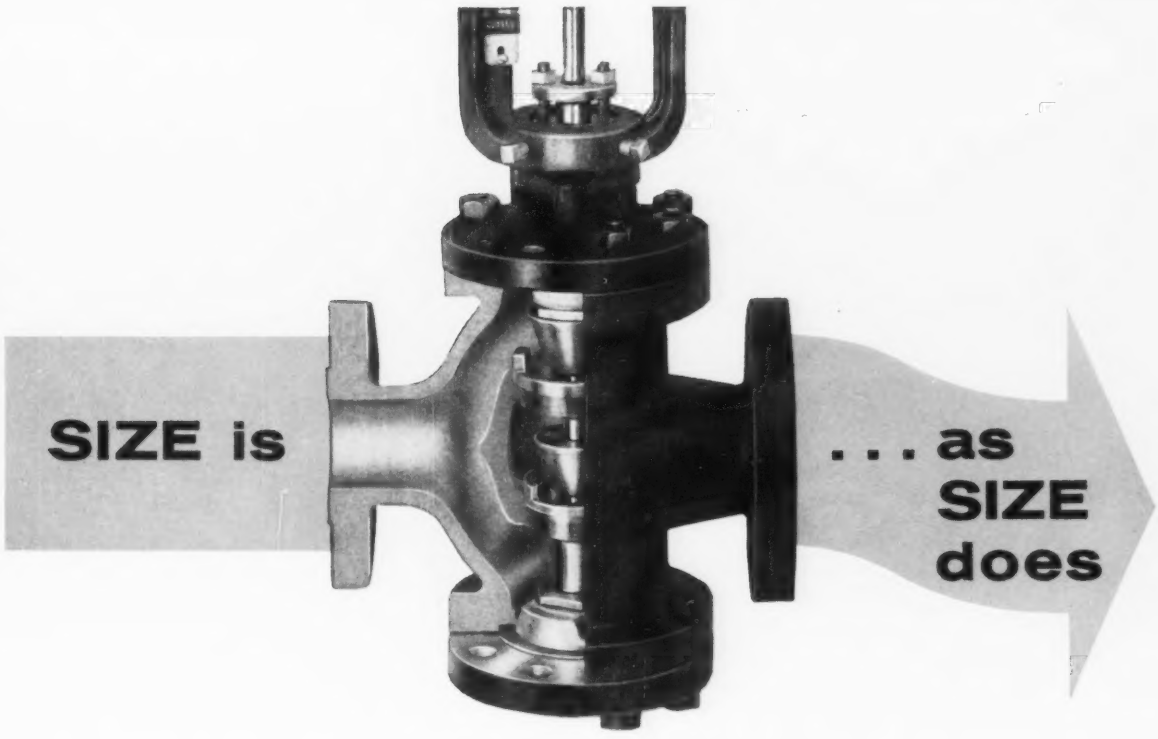
Neoprene jacketing

613 • New compound has reduced jacket moisture-absorption rate in single-conductor power cables by 50%, according to manufacturer. Reduction of moisture absorption is said to improve other physical properties of the neoprene jacket: tensile strength, aging and resistance to oil. —*General Electric Co, Construction Materials Div, Bridgeport 2, Conn.*



Adjustable bellows coupling

614 • Unit allows precision adjustment on sensitive shafts of servo motors, resolvers and synchros, manufacturer claims. It is also designed



C_v is the thing to see

Take a hard look at fundamentals when you buy diaphragm control valves.

Valves of the same size won't necessarily deliver the same *amount* of valve performance. Flow capacity, not nominal size, is the dollar dimension to look at.

K&M valves provide the largest flow coefficient available. That means, in some cases, you can use the next smaller size at a worthwhile saving in dollars. In all cases, K&M's higher C_v produces a smaller pressure loss in the body; it places the flow restriction where it belongs . . . at the controlled inner valve.

Averaging 140% of cross-sectional pipe area K&M valves provide more space for fluids to flow . . . smoothly, freely with less turbulence.

Result—you get what you are really after . . . better controllability at lower cost.

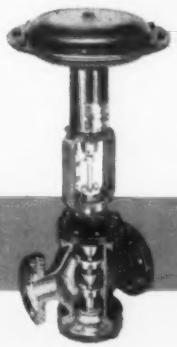
Why not size up your control valve buying decisions on a real—not nominal—size basis?

Request Bulletin CV53

C_v COMPARISON TABLE

Valve Size	K&M	Valve B	Valve C
¾"	10.9	8.4	8
1"	17.3	14.9	12
1½"	39.1	33.2	28
2"	61	57	48
2½"	97.7	71.0	72
3"	150	116	100
4"	219	197	165
6"	500	364	360

Based on the maximum Cv at rated travel through the valve body. From manufacturers' most recent slide rules or tables.



K&M

diaphragm control valves

Our 79th Year

KIELEY & MUELLER, INCORPORATED

Oldest Pressure and Level Control Valve Manufacturer
64 Genung Street, Middletown, New York

O.A. 1719-R

Here's How to Handle Corrosives at High Peripheral Speeds

CHEMLON YARN PACKING STYLE C-30 Made of TEFLON* FIBER BY "JOHN CRANE"

Chemlon Yarn Style C-30 extra tough packing gives you two important advantages not provided by other types of braided or molded Teflon packing: 1) positive sealing efficiency at high peripheral speeds; 2) cooler running stuffing box under severe service conditions.

Style C-30 can be used to handle the most destructive acids, alkalis or solvents. The excellent thermal properties of Teflon, combined with the softness, resiliency and fluid retentive properties of fine fiber construction, adapt it to high temperature conditions to +300°F. The packing is made firm and dense by means of a special process which eliminates *large* voids.

HERE'S PERFORMANCE PROOF:—Fluid handled: 45% H_2SO_4 (impure) at 170°F.—Operating conditions: 1¼" pump shaft at 1700 rpm. or 555 fpm. peripheral speed. Results: 46 days good service. Previous best service record 7 to 10 days.

Chemlon Yarn Packing Style C-30 is available in spool or coil form, in a wide range of sizes from ⅛" up. *Can be lubricated with Teflon suspensoid or various types of lubricants.*

Send for Bulletin No. P. 325. Crane Packing Co. 6430 Oakton, Morton Grove, Ill. (Chicago Suburb) In Canada: Crane Packing Co. Ltd., Hamilton, Ontario

**DuPont Trademark*

JOHN CRANE **CRANE PACKING COMPANY** 38 YEARS INDUSTRIAL PROGRESS

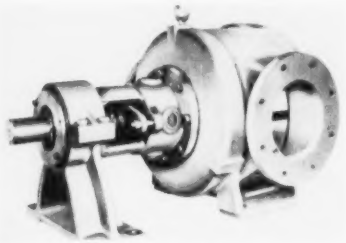
OFFICES IN ALL PRINCIPAL CITIES

Equipment News

Begins on page 152

for 360-deg continual rotation and adjustment.

Range of adaptability is for four basic shaft sizes. Unit can be applied on pin- and clamp-type hubs, is made of stainless steel.—*PIC Design Corp, 477 Atlantic Ave, E Rockaway, N. Y.*



High-efficiency rotary pump

615 • Portable, audible unit has a capacity range of up to 1200 gpm. Applications include transfer, metering of viscous and thin liquids, other services involving pressures to 100 psi.

Minimum sealing surfaces with optimum rotor and idler dimensions for any given viscosity are said to reduce drag, give efficiencies as high as 90%. Direction of flow may be reversed regardless of shaft rotation.—*Seven Machine Products Corp, 1800 W Fulton St, Chicago 12, Ill.*

For more details on these items, use post cards p 157. Identify your request with item number.

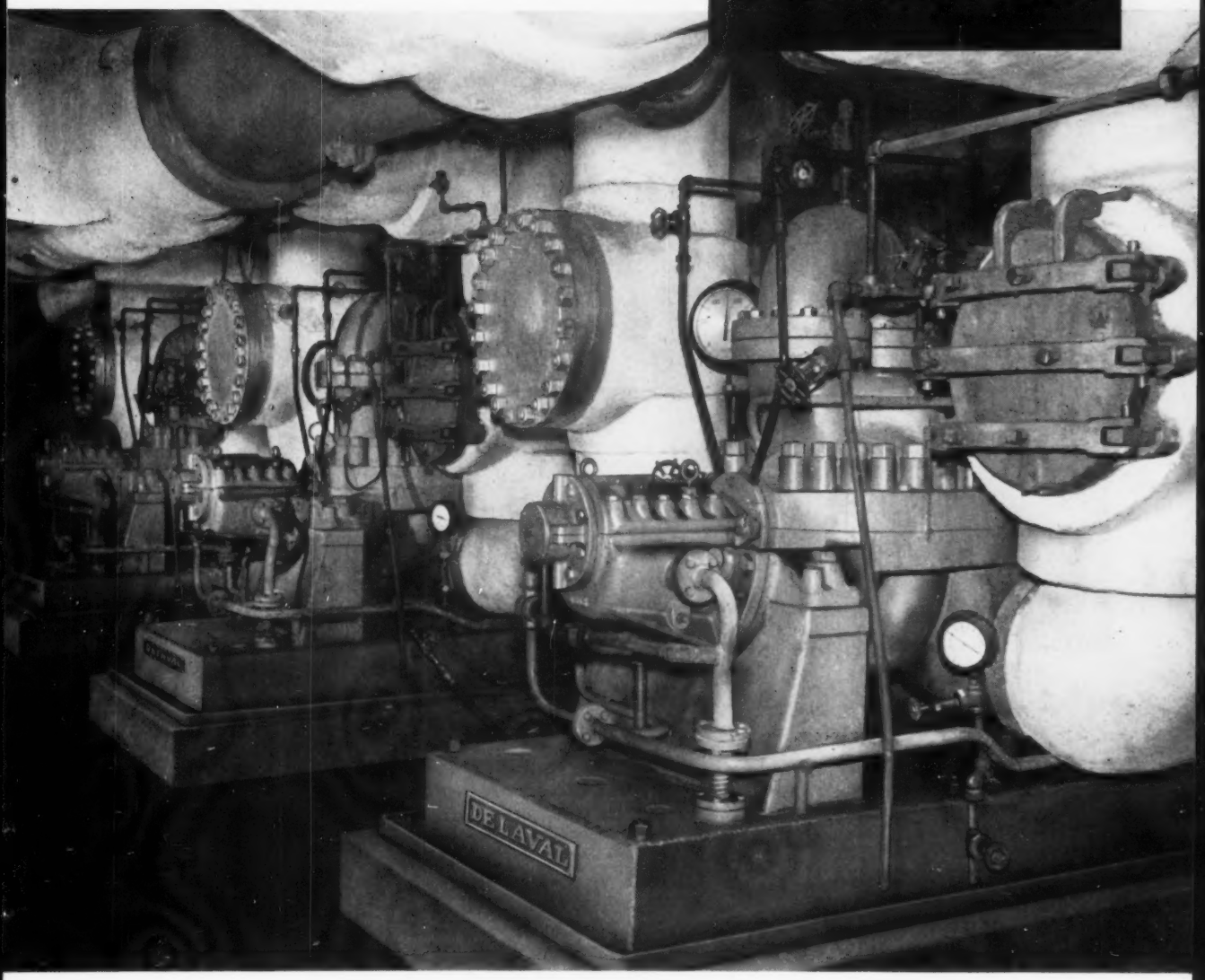
Dielectric test set

616 • Features of high-voltage detesting equipment include safety provisions, reliable operation, good output-voltage regulation and compact design, according to manufacturer. Unit measures dc at voltages up to 100 kv when applied to insulation of electrical equipment such as generators, transformers, bushings.—*James G Biddle Co, 1316 Arch St, Philadelphia 7, Pa.*

Con Edison *reorders*

DE LAVAL

BOILER FEED PUMPS



The three De Laval Oppeller Pumps, shown in the photograph, do a dependable job of handling boiler feedwater at the East River Station of the Consolidated Edison Co. of New York. These three-stage pumps, with double-suction in the first stage, have a capacity of 2,000 gpm and operate at a discharge pressure of 620 psig. As proof of their reliable performance, Con Edison has ordered two identical units for the expansion of this station *plus* similar pumps for their Indian Point nuclear generating station.

Excellent for *medium* pressure and temperature service, De Laval Oppeller Pumps are designed with opposed impellers that balance axial thrust. Standard design features include sleeve bearings and labyrinth wearing rings which assure long economical service.

For *high* pressure, *high* temperature boiler feed service, De Laval offers the barrel-type pump . . . a single-suction, radially split diaphragm type multi-stage pumping unit inside a forged steel barrel.

For more data on these dependable pumps, write for Catalogs 1502 and 1506

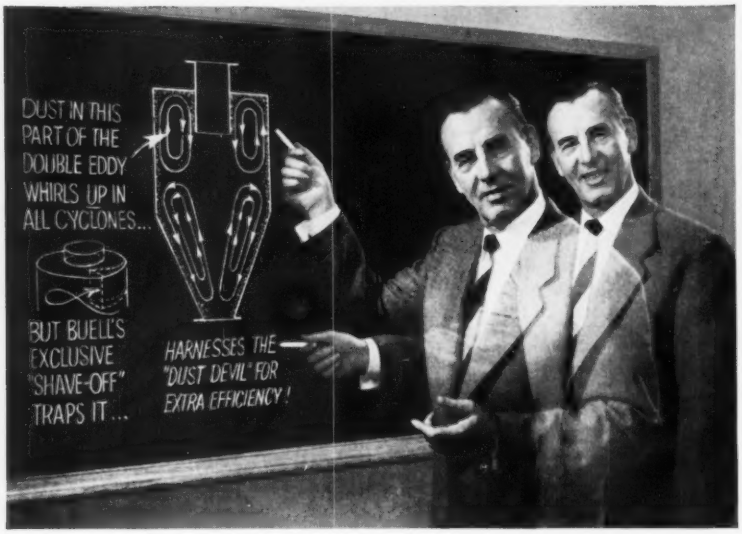
DE LAVAL *Boiler Feed Pumps*

DE LAVAL STEAM TURBINE COMPANY

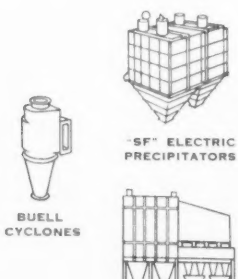
815 Nottingham Way, Trenton 2, New Jersey

DL 413

Mastering the double-eddy dust devil leads to extra dust collection efficiency!


DUST IN THIS PART OF THE DOUBLE EDDY WHIRLS UP IN ALL CYCLONES...
BUT BUELL'S EXCLUSIVE "SHAVE-OFF" TRAPS IT...
HARNESSES THE "DUST DEVIL" FOR EXTRA EFFICIENCY!

Only Buell Cyclones have the "Shave-off" that removes the fines carried in the double-eddy currents, minimizes reentrainment, assures measurably higher dust collection efficiency! Other exclusive extra-efficiency features include *large-diameter* design that eliminates bridging and clogging, proper proportioning for maximum dust separation from the gas stream, extra-heavy-gauge, wear-resistant construction, Buell-designed manifolding that minimizes draft loss, minimizes scouring and eddying. For more information send for a copy of the booklet, "The Exclusive Buell Cyclone." Dept. 50-F, Buell Engineering Company, Inc., 123 William Street, New York 38, N. Y.



buell®

Experts at delivering Extra Efficiency in

DUST COLLECTION SYSTEMS

My biggest boner

The Explosives Co had an unusual problem in loading sea-going ships because the Rocky Shore Line permitted no beach-level dock installation. Instead, the magazine had to be located on the Rocky Mountain side where a bench was blasted out to receive it. Gap between dock and magazine was spanned by an endless chain conveyor, much like the chain that hauls logs up the slide into the second story of a saw mill. But each section of chain had a section of hardwood plank bolted on it.

To start the chain, a 30-hp motor with 8-ft flywheel got the mass moving. Then as the explosives were deposited on the planks, the weight on topside moved the chain down in accelerated motion. To control the fully loaded chain, a band brake with wood inserts was tightened with a toggle triggered by a wood billet, like a baseball bat.

One hot day we didn't make much progress. No one wanted to yell "uncle" at dockside for fear of ridicule from the magazine men. So, every one speeded up his tempo until the sweat really oozed from every pore. Finally, action had to be taken —the ship's crew just couldn't handle the material on the zigzag chutes leading down to the lower holds.

When the brake was applied, the dried-out basswood caught fire from the nearly red-hot brake rim. And fire is an unwanted calamity in high-explosive plants.

Somebody grabbed the drinking-water bucket and doused the full slug of glacier-supplied water onto the brake-flywheel assembly. There was a loud "crack" as the flywheel broke into two sections as if hit by a giant sledge hammer.

P C Ziemke, *Clinton, Tenn.*

Annunciator system with no moving parts for utility generating stations will get first application in 1958 when Public Service Electric and Gas Co of N. J. uses it to monitor 560 critical quantities in a new 580-mw Bergen station. System was developed by Westinghouse Electric Corp.

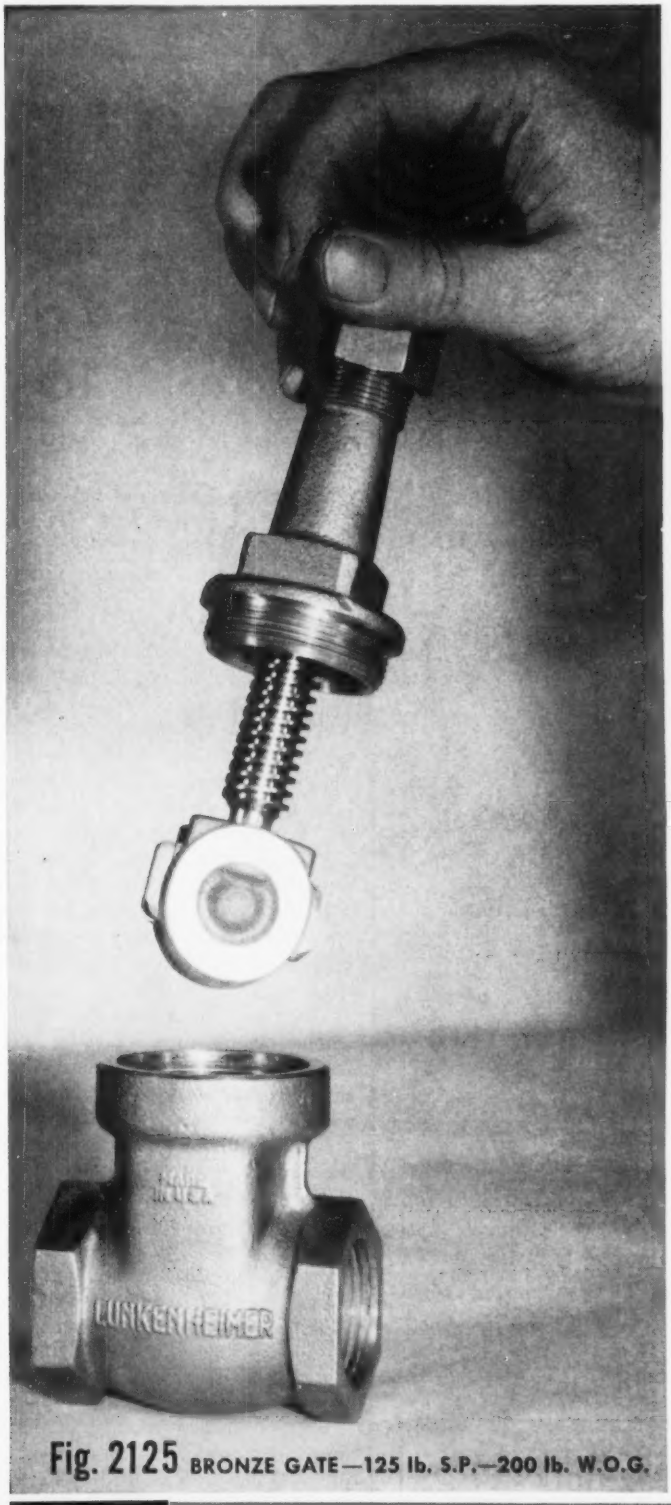


Fig. 2125 BRONZE GATE—125 lb. S.P.—200 lb. W.O.G.

SEE WHY

LUNKENHEIMER BRONZE GATE VALVES CUT MAINTENANCE

What you pay to maintain a valve can exceed its original cost many times over. That's why it pays to examine the maintenance-saving features of Lunkenheimer Bronze Gate Valves.

Stems are made of Stemalloy®, an exclusive Lunkenheimer alloy that assures longer stem thread life. Integral seats are precision tapered to insure perfect seating. Discs are compounded for long, wear-resistant service, machined to a high finish for smooth, trouble-free operation.

Let your Lunkenheimer Distributor show you the maintenance-saving features of Lunkenheimer Bronze Gate Valves and why you can't find the cost of a valve on a price list...Or write The Lunkenheimer Co., Cincinnati 14, Ohio.

LUNKENHEIMER QUALITY

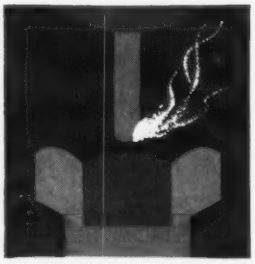
LUNKENHEIMER®

THE ONE *Great* NAME IN VALVES

THE STEAM
IS HOTTER

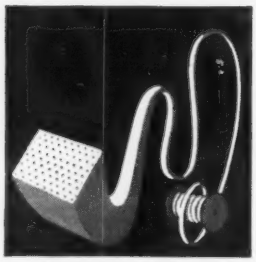
Modern boilers are producing steam at higher temperatures. Old-time valve stem packings just can't stand the gaff.

THE PRESSURE
IS HIGHER



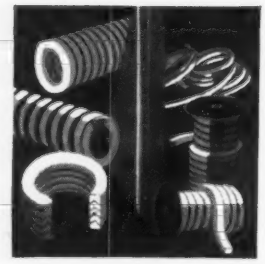
Rugged construction is a must in modern valve stem packings. R/M has designed the ruggedest: braided asbestos, with Monel and Inconel wire reinforcement, over a high-temperature resistant plastic core.

R/M LICKS
YOUR PROBLEMS



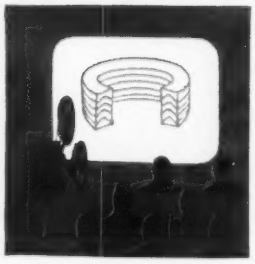
Practically no organic materials to burn, lubricants ground in during manufacture—good at stuffing box temperatures to 1150°F.

7 BASIC TYPES
CUT COSTS
AND INVENTORY



Big 7 Packings give custom-built performance in 95% of your packing applications, eliminate stocking problems, lower maintenance costs, cut downtime, permit preventive maintenance. Sold only through authorized R/M distributors.

PACKING CLINIC
GIVES FULL
DETAILS



Color movie is part of R/M Packing Clinic. Learn how three or four R/M Big 7 Packing Types may meet 95% of your needs. Ask your authorized R/M distributor for a showing!

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BIG 7 PACKINGS
RAYBESTOS-MANHATTAN, INC.
PACKING DIVISION, PASSAIC, N.J.
MECHANICAL PACKINGS AND GASKET MATERIALS

RAYBESTOS-MANHATTAN, INC., Mechanical Packings • Asbestos Textiles • Industrial Rubber • Engineered Plastics
Sintered Metal Products • Abrasive and Diamond Wheels • Rubber Covered Equipment • Brake Linings
Brake Blocks • Clutch Facings • Industrial Adhesives • Laundry Pads and Covers • Bowling Balls

F-R lubes

continued from page 107

Conclusions to date can be summed up as follows:

(1) F-R fluids tested have no adverse effect on the bearing performance within the present design limits. Babbitt temperatures, oil flows, film thicknesses are comparable for all fluids tested.

(2) Synthetics showed more foam in the oil tank than petroleum. And there was less air entrained in the fluid at the thrust bearing using the synthetics. This indicates that the latter detrain air more rapidly than petroleum.

(3) Water, about 1% by volume, was poured into the tank. It evaporated during 24 operating hours.

(4) Hydraulic system in turbine was normal for all lubricants. Pump pressures were higher on the turbine system because of the turbine type oil pump operating with the higher density synthetic fluids.

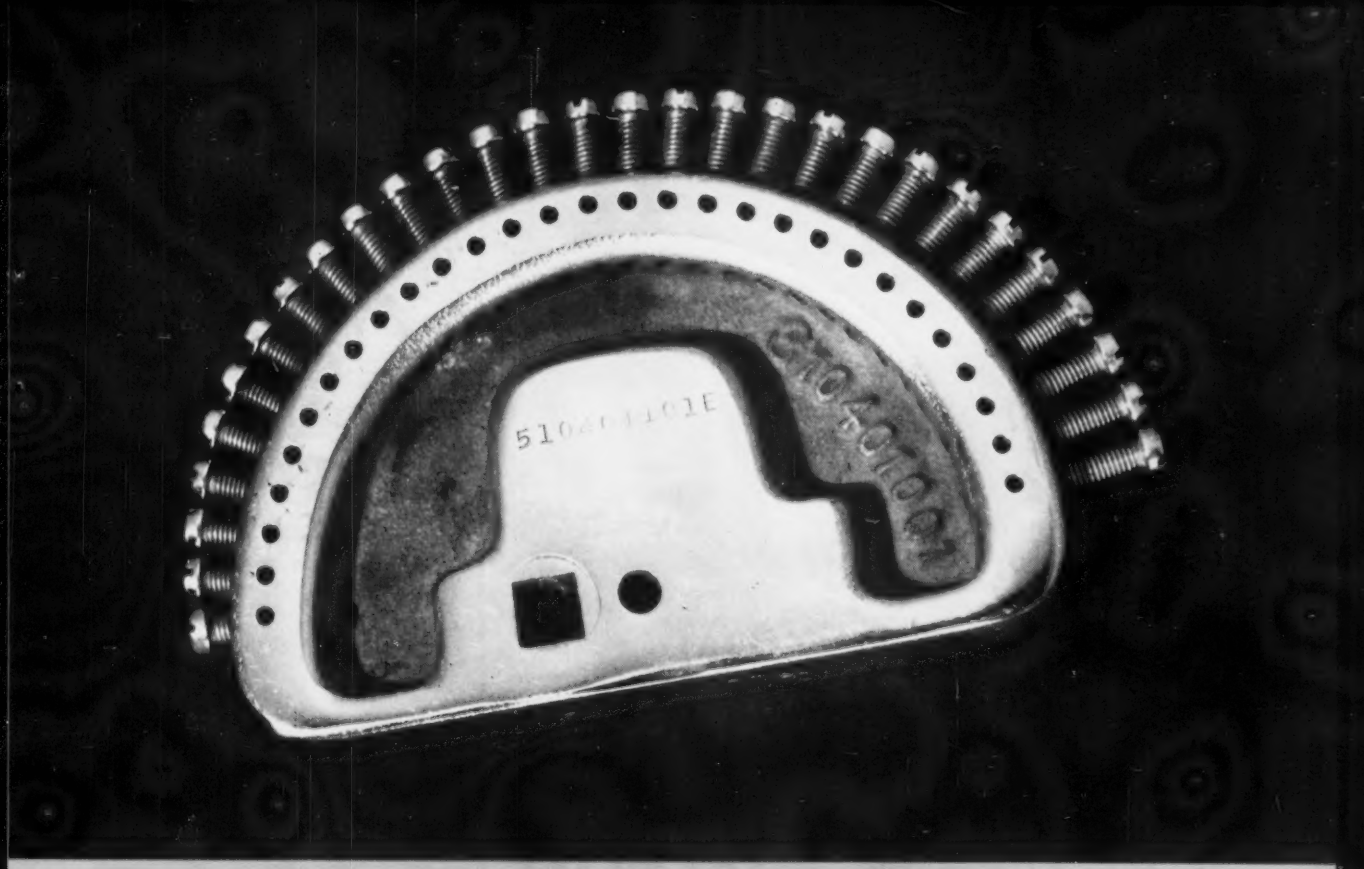
(5) Some pipe joints leaked when the chlorinated biphenyl phosphate-ester fluid was tested. Piping had been flushed with *Cassis* fluid, and the synthetic fluid itself, before test was started. All moving seals were replaced with appropriate materials that would stand up to the synthetics. No other difficulties were met in the line of attack on the oil system's static parts.

(6) No conclusions could be reached at this time regarding long-term synthetic-fluid performance. Lab tests indicate superior oxidation resistance and hydrolytic stability for the chlorinated biphenyl phosphate-ester fluid.

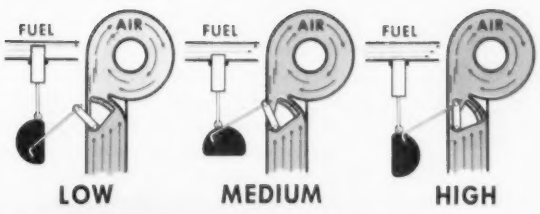
Future, in my opinion, looks bright for F-R fluids. Field experience, preferably in a turbine designed specifically for operation with a synthetic lube, will give us more definite and significant answers.

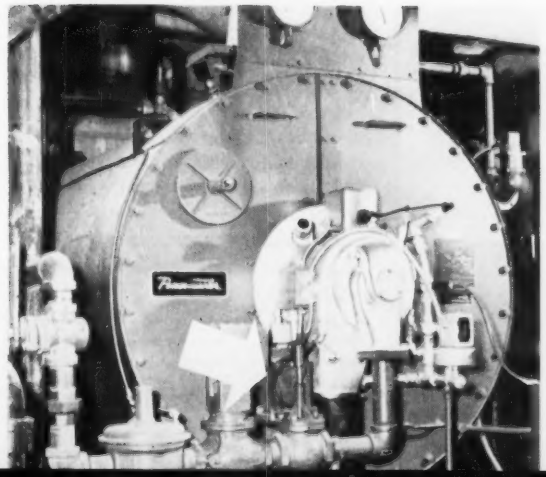
Reactor vessel for the prototype nuclear-propulsion plant for nation's first atomic-powered surface-ship program has been shipped by Foster-Wheeler Corp to the Naval Reactors Facility at Arco, Idaho.

Hydroelectric construction activities continued to accelerate in Canada during 1957. A total of 1,501,560 hp of new capacity was installed.



this Powermaster Cost-saving Automatic Modulation S-T-R-E-T-C-H-E-S BOILER-ROOM DOLLARS





By means of the cam shown above, fuel and air are properly proportioned *automatically* for clean, efficient controlled combustion over the entire firing range of Model 3 *Powermaster* Packaged Automatic Boilers. With this instantly responsive and accurate modulating control of the oil or gas firing rate, *Powermaster* handles load swings with negligible variation in steam pressure, and maintains uniformly high firing efficiency at infinitely variable loads from 20% to 100% of normal rating. Result is continuous close control of steam pressure and temperature, savings in fuel and boiler cleaning, and dependable boiler performance. Be sure to investigate this *Powermaster* feature when selecting boilers for modernization or new steam requirements for processing or heating.

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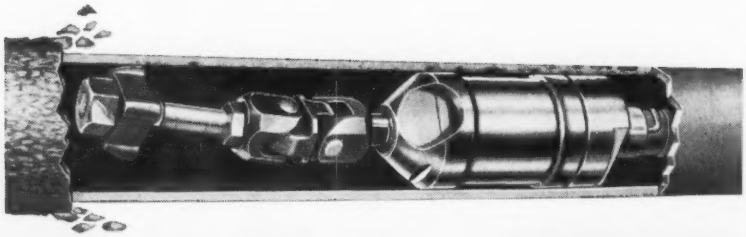

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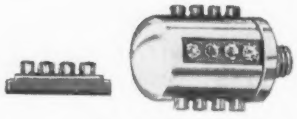
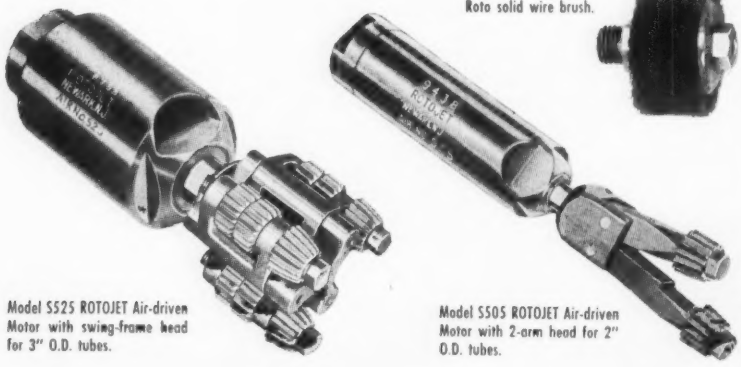
Roto expanding brushes and heads have separately replaceable wearing elements. These inexpensive parts save time, money, and critical materials. Send for details.



Roto expanding brush, showing a replaceable brush element. Brings down tube cleaning cost. Maintains high cleaning efficiency.

Roto solid wire brush.



Model S525 ROTOJET Air-driven Motor with swing-frame head for 3" O.D. tubes.

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Technical briefs

Begins on page 148

Size of generating units affects the total investment, fuel costs, operation and maintenance, and the amount of transmission installed. To determine the economic unit size to install at the next plant, the costs of adding units in steps of 15, 20 and 25% of the total generating capacity were studied.

The report concludes that for the various alternate expansions studied, the 15% expansion cost was 1 to 2% less than the 20% expansion. It was between 3 and 6% less than the 25% expansion for the case of tie capacity equal to the size of the largest unit and a maximum loss-of-load probability of three days in ten years.

If maximum loss-of-load probability is allowed to increase to six days in ten years, then the 20% expansion becomes about 1% less expensive than the 15% expansion, and about 4% less expensive than the 25% expansion.

The small cost differential between the various patterns indicates that the final choice may be influenced by other considerations. *AIEE paper, No. 58-141*

Atomic power

Nuclear power plant operating experience. *By J M Yadon, Westinghouse Electric Corp*

This discussion translates the experience gained from operating a small pressurized-water-cooled water-moderated plant used as a test facility to commercial practice. Many of the plant conditions and operating practices discussed apply equally to other types of reactors, but, in general, no effort is made to specify whether the item is unique to the pressurized-water plant.

The S1W plant was placed in operation in the spring of 1953 and has been refueled once. During this period the equivalent of well over 50 million kwhr of useful energy has been developed. This number is equivalent to shaft horsepower available, not reactor output, and is significant from the standpoint of demonstrating that a first of kind plant has operated with a good availability factor, even though it is used

Directions for ordering papers on page 182

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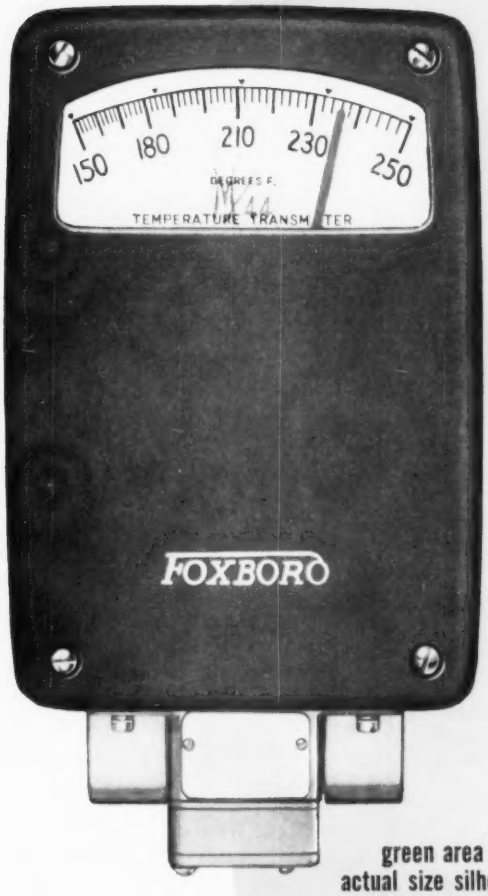
engineered for fast, sensitive response under roughest field conditions — uses any filled thermal system.



green area is actual size silhouette of the new M/44

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The M/44 is made with standard performance-proved Foxboro components, simply and conveniently arranged in a weather proof steel case. Changing range or type of thermal system can easily be done in your own plant.

Thanks to its rugged construction, the new M/44 is unaffected by vibration, sudden shock, or corrosive atmosphere. Even in the event of air supply failure, this instrument continues to indicate process temperature.

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Class III Gas Pressure (−450° to +1000° F)
Applicable to ranges beyond the limits of other filled systems. Uniform scale. Bulb has long sensitive section; permits useful averaging measurements.

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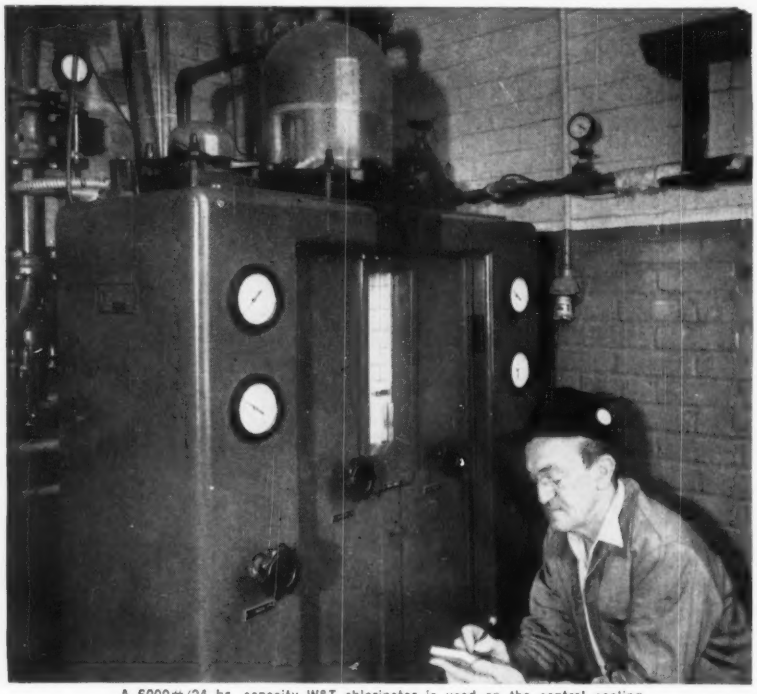
TEMPERATURE MEASUREMENT AND CONTROL



A 6000#/24 hr. capacity W&T chlorinator is used on the central cooling water system at Marcus Hook, Penna. refinery of Sinclair Refining Company.

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the economical way to prevent slime in cooling waters

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Technical briefs

Begins on page 148

only for testing and crew training.

Experience shows that a nuclear plant can be operated by the same caliber personnel as used in present day power plants, but more highly-trained operators make it possible for them to make valuable contributions to plant design and to assist in analysis of plant performance. *AIF paper, No. 57-AIF-22*

Status report on the engineering test reactor. *By R L Doan, Phillips Petroleum Co*

The ETR went critical on September 19, 1957, three weeks after the official termination of construction activities. This was preceded by extensive pre-operational tests of various reactor components and the cooling system. Low power testing is now in progress involving equipment debugging, rod calibration, flux distribution measurements, void and temperature coefficient determinations, etc. Installation of major experimental facility loops in core positions will necessitate substantial reactor down time and subsequent careful study of the resulting change in core conditions.

The paper goes on to discuss the more important problems that have been encountered in the pre-operational and operational tests of the reactor thus far. *AIF paper, No. 57-AIF-2*

Operating experience with the sodium reactor experiment. *By F E Faris, Atomics International, NAA, Inc*

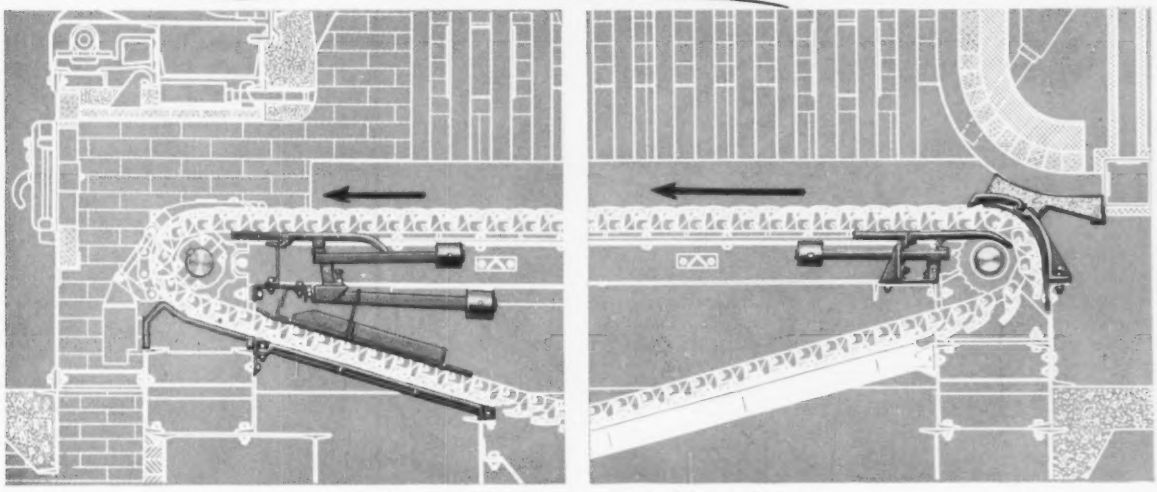
Some of the main conclusions to be drawn from the operation of the SRE thus far are as follows:

(1) The plant has performed well. Stability of the reactor is particularly gratifying. (2) Observations during the two power runs showed that adding flow programming devices in the sodium systems and a pump to reduce leakage between the plenum feeding the fuel channels and that feeding the spaces between moderator cans would be desirable. These modifications will significantly reduce thermal stresses during operation at high power levels.

(3) It has been relatively easy to

Directions for ordering papers on page 182

DOWN WITH EXCESS AIR!



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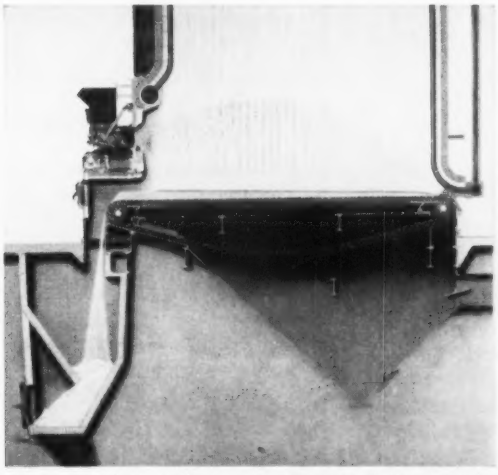
They decrease excess air.

Automatic Air Seals Exclusive With Detroit RotoGrate Stokers Reduce Excess Air to 22% and Lower



Detroit RotoGrate Stoker — an advanced design spreader stoker with forward moving grates, for medium and large boilers. Burns all ranks of bituminous coals and lignites without special preparation . . . also many waste or refuse fuels, either alone or in combination with coal. Efficiency is high — maintenance low.

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Technical briefs

Begins on page 148

maintain the oxygen content of the sodium at about 10 ppm with the cold traps under normal conditions. (4) Maintenance operations associated with removing a damaged fuel element from the core and removing, cleaning and replacing the disposable cold trap have been relatively easily accomplished. (5) The rather slow approach to full power, required for the SRE because of its experimental nature, should not be required for future plants designed with the information available from the operation and testing of the SRE. *AIF paper, No. 57-AIF-24*

Capital equipment requirements. *By F Warren, Pickard-Warren-Lowe Associates*

This paper presents some highlights from a report just completed for the Atomic Industrial Forum. It deals with nuclear reactor systems in two major aspects: capital equipment and fuel cycle functions.

The new suvey not only reexamines the next ten years' market for nuclear products, on the basis of plans initiated since early 1955, but also reviews the prospect of sizable foreign programs for nuclear power construction which may involve U. S. technology and equipment. *AIF paper, No. 57-AIF-14*

TO OBTAIN COMPLETE TEXT

Material for these abstracts comes from the following sources unless otherwise stated. Order complete paper from source, not POWER.

American Power Conference, 20th anniversary meeting. Identified by initials APC and obtainable through purchase from Director, APC, Illinois Institute of Technology, Chicago 16, Ill.

Atomic Industrial Forum, 4th annual conference: The 1957 Nuclear Industry — problems and progress. Identified by initials AIF, and obtainable by purchase from AIF, 3 E 54th St, New York 22, N. Y.

American Institute of Electrical Engineers. Identified by initials AIEE and obtainable through AIEE, 33 W 39th St, New York 18, New York.

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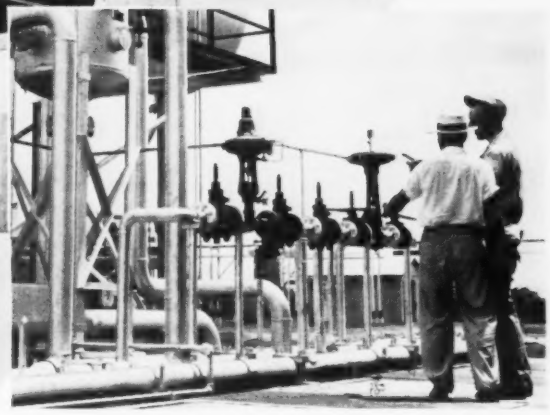

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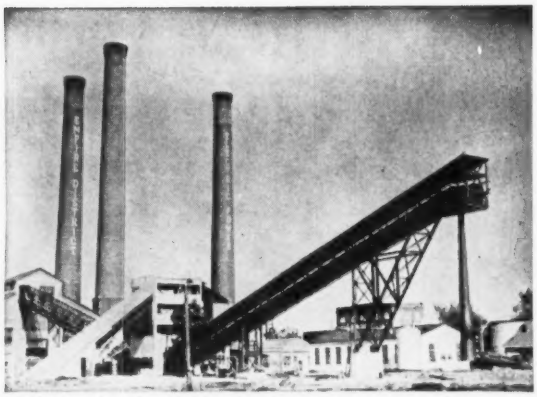

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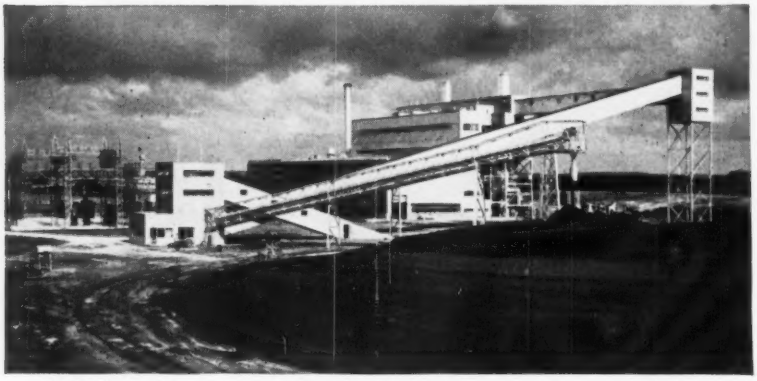

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Free literature

Begins on page 157

Gives applications, operational characteristic curves. I-T-E Circuit Breaker Co, Small Air Circuit Breaker Div, Philadelphia 30, Pa.

HEAT EXCHANGERS

12 **Plate heat exchangers** are subject of 8-p bulletin. Lists features, complete dimensions, mechanical specs. The De Laval Separator Co, Poughkeepsie, N. Y.

13 **Cooling towers,** propeller-fan type, are described in 8-p bulletin EC-500. Gives rating data, dimensions and diagrams for belt-drive, direct-drive and take-apart models. Installation info is included. Halstead & Mitchell, Bessemer Bldg, Pittsburgh 22, Pa.

14 **Packing arrangements** for cooling towers are discussed in 8-p booklet. Comparative values of redwood bars and grids with different spacing are covered. J F Pritchard & Co, 4625 Roanoke Pkway, Kansas City, Mo.

MAINTENANCE EQUIPMENT AND MATERIALS

15 **Corrosion-proof** polyvinyl-chloride linings are covered in 12-p handbook. Includes a table comparing conventional and unplasticized linings, evaluated at 70, 120 and 160 F. Kaykor Industries, Inc, Div of Kaye-Tex Mfg Corp, Yardville, N. J.

16 **Neoprene liquid-rubber** coating with built-in primer is subject of 4-p bulletin. Includes data on how and where to apply it. Charleston Rubber Co, Stark Industrial Park, Charleston, S. C.

17 **Industrial lighting** is covered in 8-p reflector lamp and 24-p incandescent-lighting booklet. Include photos, specs. Sylvania Electric Products Inc, 1740 Broadway, New York 19, N. Y.

18 **Industrial stethoscope** is described in 8-p bulletin. Unit is used for testing machinery in operation, detecting leaks, nondestructive testing of welds. M Paquet & Co, Inc, 17 Battery Place, New York 4, N. Y.

19 **Sludge dispersant** and soot remover are subjects of 4-p folder. Discusses sludge and soot formation and treatment. Western Chemical Co, 713-15 Washington St, Kansas City 5, Mo.

MATERIALS HANDLING

20 **Ceramic magnet pulleys** for tramp-iron separation in belt-conveyor systems are discussed in 4-p bulletin 1021. Includes specs, diagrams. Stearns Magnetic Products, 635 S 28th St, Milwaukee 46, Wis.

21 **Bucket elevators** are described in 36-p bulletin. Includes simplified

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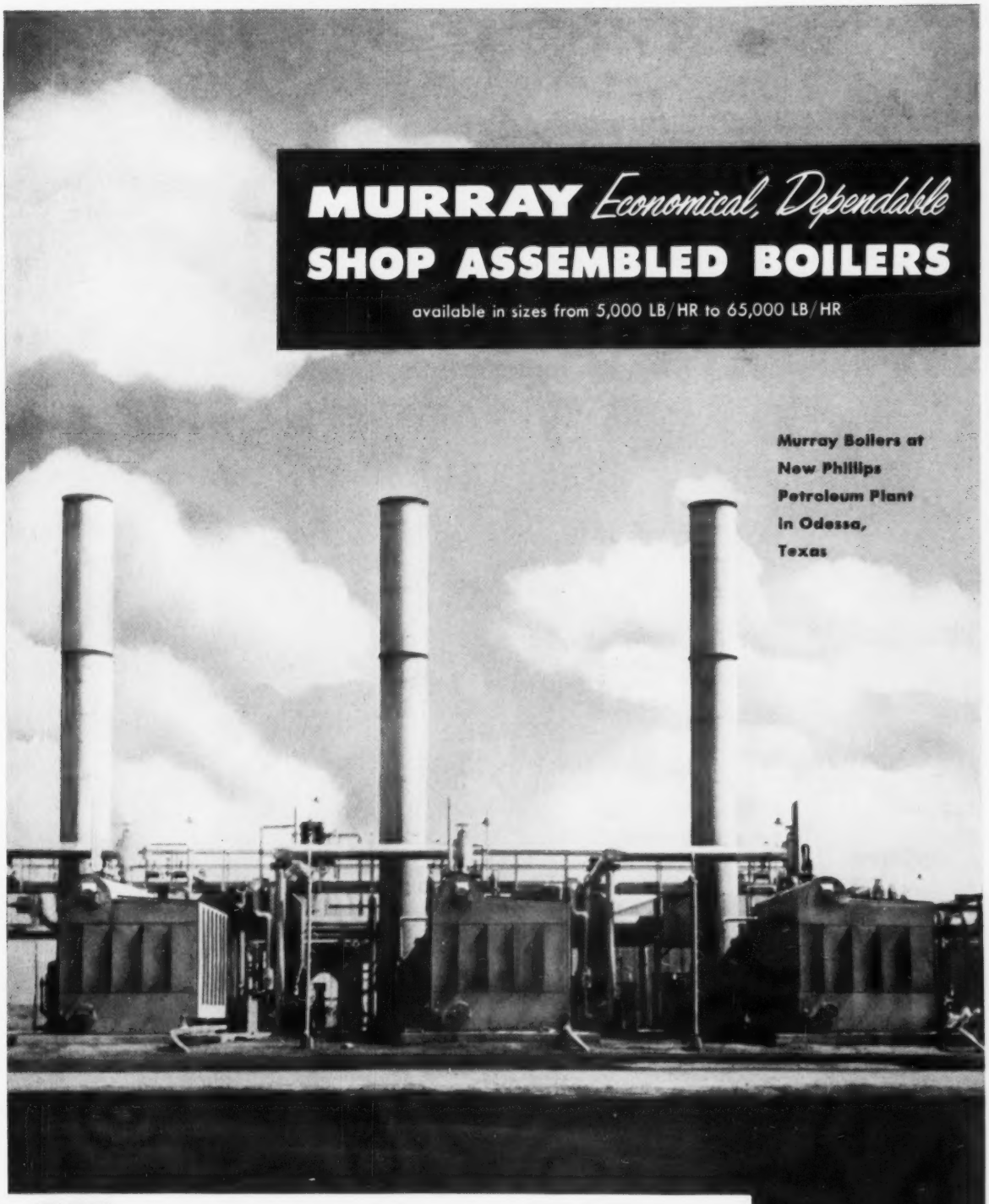

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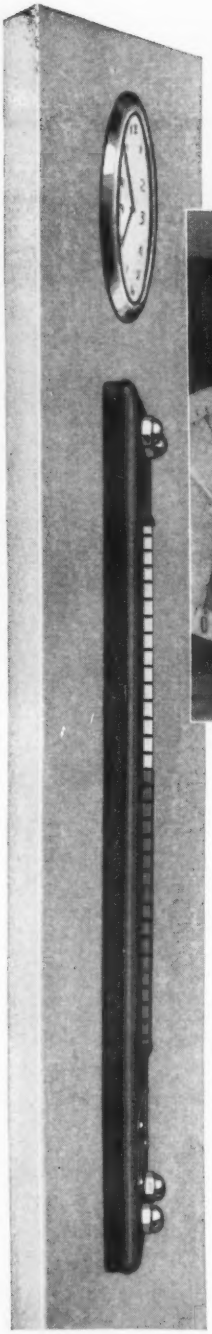

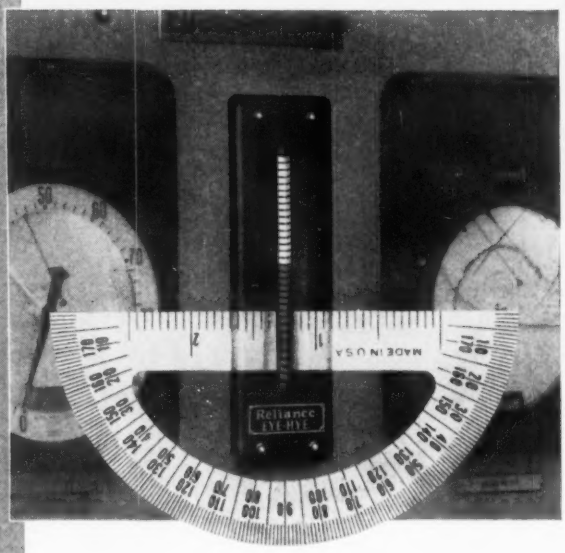

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Free literature

Begins on page 157

selection data, dimensions, photos and drawings for each of various types. Chain Belt Co, Dept PR, Milwaukee 1, Wis.

22 **Overhead traveling cranes,** double- and single-girder types in top-running and underhung designs, are subject of 10-p bulletin 900. Includes full specs. Robbins & Myers, Inc, Hoist & Crane Div, Springfield, Ohio.

23 **Electric hoists** are covered in 8-p bulletin DH-133D. Units with capacities of 500 to 4000 lb are described, illustrated. American Chain & Cable Co, Inc, 929 Connecticut Ave, Bridgeport 2, Conn.

MECHANICAL TRANSMISSION

24 **Magnetic drives** are discussed in 8-p booklet. Gives operating curves, selection and accessory charts and specs. Whitney Chain Co, Hartford, Conn.

25 **Selective-speed drives** are described in 8-p bulletin 11-1. Describes motor-speed control from ac. Photos show units and installations. Century Electric Co, 18th & Pine Sts, St Louis 3, Mo.

26 **Couplings** are subject of 12-p catalog C-210-A. Includes sizes, specs, ratings for die-cast, steel, fixed-bore and bushed types. Browning Mfg Co, Maysville, Ky.

CONTROLS, METERS AND INSTRUMENTS

27 **Analog computer,** a portable computer-center unit, is illustrated in 8-p brochure. Includes graphs, descriptions, application info. Mid-Century Instrumatic Corp, 611 Broadway, New York 12, N. Y.

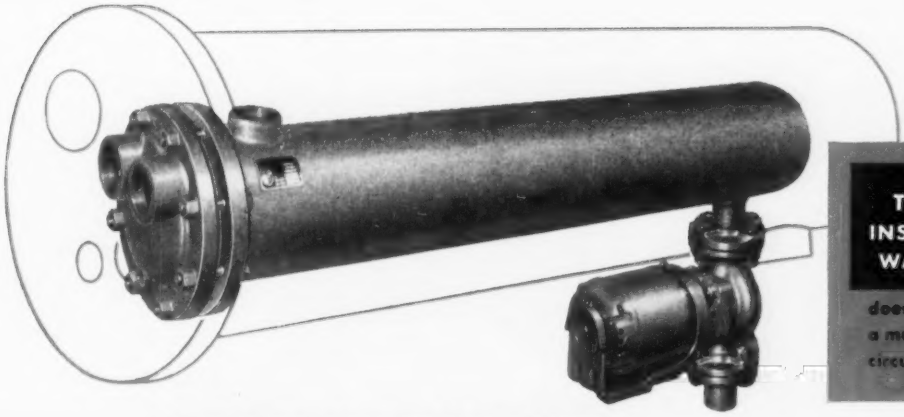
28 **Pressure regulators** and how to select them, is covered in 28-p bulletin 401. Introduction describes application of self-operating and pilot-type units. Tables speed comparison. Kieley & Mueller, Inc, 64 Genung St, Middletown, N. Y.

29 **Signaling controller** for electrolytic conductivity is subject of 2-p data sheet ND47-95(1). Gives specs, applications, descriptions. Leeds & Northrup Co, 4934 Stenton Ave, Philadelphia 44, Pa.

30 **Gages with ranges** from 15 to 20,000 psi are listed in 48-p catalog G-58. Includes complete engineering data, selection tables for plant and instrumentation applications. Kunkle Valve Co, 121 S Clinton, Fort Wayne 2, Ind.

31 **Rotameters** for pressures to 5000 psi, flow-rate equivalents to 3000 gpm of water are subject of 8-p bulletin 130. Gives construction info, dimensions, capacities. Brooks Rotameter Co, Box 432, Lansdale, Pa.

(Continued on page 188)



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The B&G Type "WU" Heat Exchanger is an extremely versatile, instantaneous water heating unit, with a wide range of applications. It is equipped with a B&G Booster which pumps boiler water through the properly baffled shell, thereby greatly increasing the capacity of the heater. Large volumes of hot water are produced by amazingly small units.

Controls service water temperature

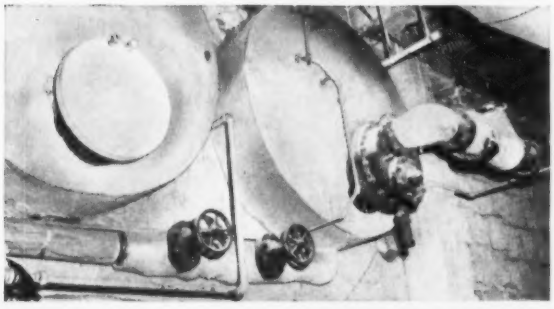
A hot water control, installed in the hot service water line, starts the Booster whenever water temperature goes below the desired degree. Boiler water is pumped through the shell of the "WU" until service water is again at the correct temperature.

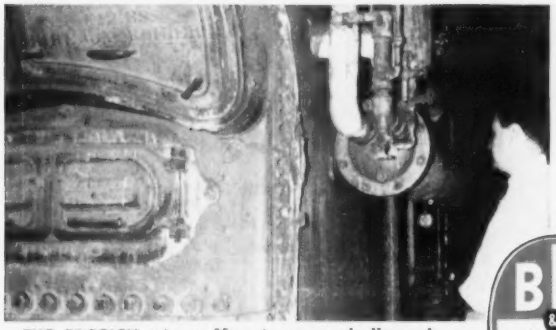
Slashes material and labor costs

Because of pumped circulation, the connecting pipes and fittings can be radically reduced in size. Material cost is trimmed to the bone and cutting and threading can be done on the job. No storage tank needed—another substantial saving.

"WU" Heat Exchangers can be installed on hot water boilers or below the water line of steam boilers.

SAVES REPLACING EXPENSIVE HOT WATER STORAGE TANKS





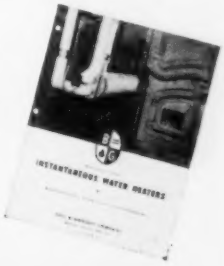
THE PROBLEM (*above*): How to economically replace two leaking hot water tanks.

THE SOLUTION (*below*): Old tanks were capped off and a compact B&G Type "WU" Instantaneous Water Heater connected to the boiler.

The photos here tell a significant story to plant managers and engineers. The "Problem" picture shows two old-fashioned hot water storage tanks, requiring replacement because of leakage...the "Solution" picture, how the tanks were replaced with a modern B&G Instantaneous "WU" Heater.

To remove and replace the two leaking hot water tanks would have been a difficult and costly job. Installing a comparatively tiny B&G Type "WU" Heater *saved hundreds of dollars* and in addition *increased the available volume of hot water!* In 12 years of operation there has never been a shortage of hot water.

Send for this booklet on the application, selection and installation of B&G Instantaneous Water Heaters.



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BELL & GOSSETT

COMPANY

Dept. FH-36, Morton Grove, Illinois

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, Toronto 16, Ontario

7 big reasons why A. O. Smith *Permaglas*® glass-protected (inside and out) smokestacks are your best investment

1. 3 to 5 times longer life than unlined steel stacks
2. corrosion resistance regardless of excess condensate
3. low maintenance — glass can't rust
4. lightweight — lower foundation cost
5. lower cost — glass protection now within reach of all
6. tough, durable — remarkable resistance to impact or abrasion
7. easy to install — no need for special equipment or highly skilled workmen

Write Dept. P-6 for the Remarkable Facts!

Through research ...*a better way*

A.O.Smith CORPORATION

PERMAGLAS SMOKESTACK SALES
PROCESS EQUIPMENT DIVISION
MILWAUKEE 1, WISCONSIN

AMERICAN
has furnished water
treatment equipment to
industry's leaders
for more than
55 years
AMERICAN
WATER SOFTENER COMPANY, Inc.
FOURTH STREET AND LEHIGH AVENUE • PHILADELPHIA 33, PA.
DEAERATORS · HOT PROCESS SOFTENERS · ZEOLITE SOFTENERS · DEMINERALIZERS · FILTERS

Free literature

Begins on page 157

32 **Manual remote controls** for valves are subject of 4-p bulletin 589. Includes photos, installation info. Stow Mfg Co, 443 State St, Binghamton, N. Y.

33 **Area meter transmitter** application is discussed in 4-p spec sheet P22-4. Table of flow ranges is included. Bailey Meter Co, 1050 Ivanhoe Rd, Cleveland 10, Ohio.

NUCLEAR ENERGY

34 **Tubing applications** in nuclear plants are covered in 6-p folder. Includes diagrams. Wolverine Tube Div of Calumet & Hecla, Inc, 17200 Southfield Rd, Allen Park, Mich.

35 **Control-rod drive** mechanism is covered in Q&A form in 10-p bulletin. Includes exploded view of the unit. Alco Products, Inc, Box 1065, Schenectady, N. Y.

36 **Radiation detection** and protection is discussed in 14-p technical booklet. Method described is photographic dosimetry. E I du Pont de Nemours & Co, Inc, Rm N-2420-2, Wilmington 98, Del.

37 **Solenoid valves** for reactors are subject of 4-p brochure. Gives photos, descriptions. Automatic Switch Co, Florham Park, N. J.

PIPING, VALVES

38 **Steel valve,** full-opening double-block and bleed nonlube type, is subject of 4-p brochure. Covers applications, installation. Kerotest Mfg Co, 2525 Liberty Ave, Pittsburgh 22, Pa.

39 **Pressure-reducing valve** is described in 2-p data sheet 1051. Gives design features, mechanical details, specs. Copes-Vulcan Div, Blaw-Knox Co, Erie 4, Pa.

40 **Union-valve** combo is described in 4-p folder WV454. Includes features, specs. Worcester Valve Co, Inc, 16 Parker St, Worcester, Mass.

41 **Reference table** lists numerous conversion factors in alphabetical order; The cardboard chart can be used on the wall, desk or in a notebook. Precision Equipment Co, 409B Ravenswood Ave, Chicago 40, Ill.

42 **Rubber expansion joints** and flexible pipe are covered in 6-p bulletin 575. Gives data for units from ½- to 72-in. ID. General Rubber Corp, Summit & Atwood Sts, Tenafly, N. J.

★ **Pressure piping** specs according to ASA, ASME Codes are summarized, related in 48-p bulletin. Simplifies process of figuring requirements for piping systems. ★Request direct on company letterhead. Babcock & Wilcox Co, Tubular Products Div, Beaver Falls, Pa.

O-B VALVES

New O-B valve for industrial service . . .

Here's a new O-B bronze valve for industrial service where frequent operation and tight shutoff are required.

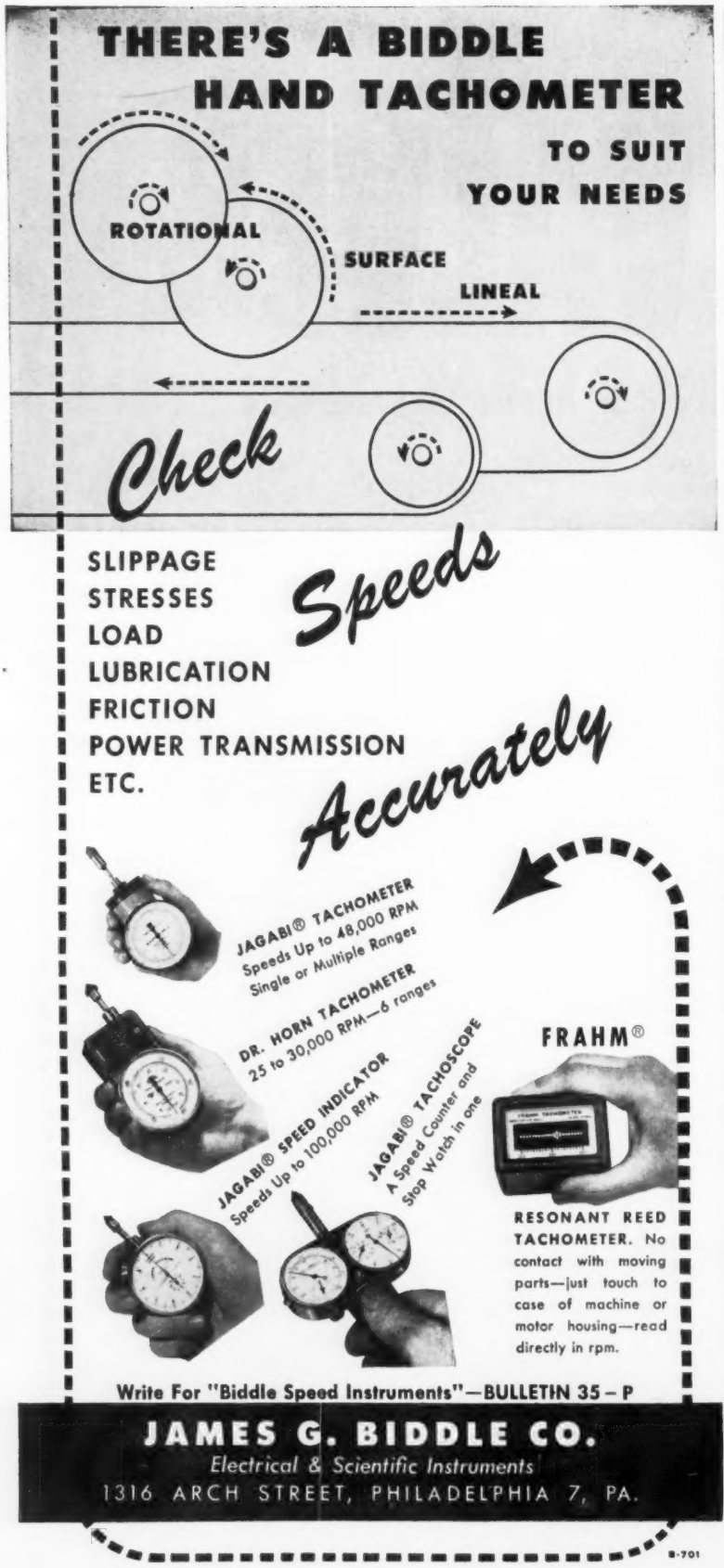
It's a valve that is easy to keep in first class condition. A union bonnet ring makes dismantling and reassembling easy and adds strength at the bonnet joint.

And it's a valve made to stay tight. The tough composition disc fits close to the seat, absorbing wear, giving extra-long service.

The No. 701 globe, and No. 702 angle, valves will give long service on industrial lines where there is up to 150 pounds working steam pressure or 300 pounds water, oil or gas pressure. They are available in sizes from ⅛" through 3".

You can buy these composition disc valves from your O-B distributor. Ask him about the complete line of bronze O-B globe, angle, check and gate valves for industrial use.

OHIO BRASS COMPANY • MANSFIELD, OHIO



Appointments

Corporation changes

Mason Products, Inc: Paul H Mason, president. **The Mercoid Corp:** Hugh Courteol, chairman; J F Chambliss, president; W L Colterjohn, vice-president and director. **Conoflow Corp:** M Mark Watkins, president; J C Koch, vice-president.

Kennedy Van Saun Mfg & Engineering Corp: Byron Pyle, president. **Babcock & Wilcox Co:** Carl Claus, vice-president. **Layne & Bowler, Inc:** Edward J Rogers, chairman; C E Ponkey, vice-president. **Hewitt-Robins, Inc:** Austin Goodyear, president. **Albert Kahn Associated Architects & Engineers, Inc:** Sol King, president.

Operations changes

Jeta Metal Fabricators, Inc, Power Equipment Div: Howard C Beyer, general manager. **Bell & Gossett Co,** Marlow Pumps Div: S R Schleicher, general manager. **W S Rockwell Co:** Stanley G Oppenheim, vice-president and general manager. **Byron Jackson Pumps, Inc,** Standard Products Div: Max L Murdock, vice-president and general manager. **Borg-Wagner Corp,** Spring Div: Arthur J Welch, vice-president and general manager.

Baldwin-Lima-Hamilton Corp, Hamilton Div: William F Boyle, general manager. **General Electric Co:** Metallurgical Products Dept, William A Reich, manager of Engineering Section; Instrument Dept, Carl W Pinkham, manager of instrument transformer engineering.

International Rectifier Corp, Heavy Duty Products Dept: Edward J Diebold, director. **Detroit Edison Co:** William G Meese, director of engineering lab and research dept.

Sales vice-presidents

Midco Valve & Fittings, Inc: Harold Michel. **Belmont Packing & Rubber Co:** John W Russell. **International Resistance Co:** George D Butler, director of sales.

General sales manager

Diamond Power Specialty Corp: J Elmer Forrest, mechanical products. **North American Aviation, Inc,** Atomics International Div:

(*Continued on page* 194)

How you cut costs with the new

TUBE-TURN LIGHT WEIGHT TAPER FACE FLANGES

The new TUBE-TURN* 125 lb. light weight, forged steel, taper face welding neck flanges (patent pending) can cut costs three ways:

1. You eliminate the hazard of breaking cast iron and semi-steel valves, fittings and equipment such as pumps and compressors, caused by overstressing the bolts to get a tight seal when regular ASA steel flanges are used.
2. You avoid the necessity of using more expensive 250 lb. valves with 300 lb. companion flanges.
3. The new flanges cost less, weigh less and take less storage space than the 150 lb. flanges they replace.

Maximum service pressures are the same as for Class 125 cast iron flanges in ASA B16.1, namely: 125 psi (gage) saturated steam; 175 psi (gage) liquid and gas (WOG) at 150°F.

Here is another example of the cost-saving advantages you realize when you specify TUBE-TURN products and buy them from your nearby Tube Turns' Distributor.

TUBE TURNS

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

tt TUBE-TURN

*"TUBE-TURN" and "tt" Reg. U.S. Pat. Off.

For more details, turn the page

The trademarks "TUBE-TURN" and "tt" are applicable only to the quality products of Tube Turns.

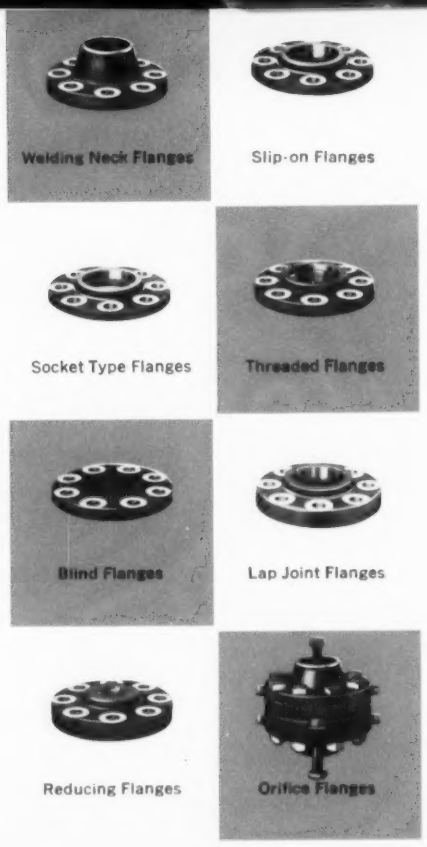
How TUBE-TURN® Taper Face Flanges give you a tighter seal without overstressing

TUBE-TURN taper face forged steel welding neck flanges conform to the 150 lb. American Standard with respect to flange diameter and drilling, but both the flange ring and tapered hub are thinned to make them compatible in strength and stiffness to Class 125 American Standard cast iron flanges with which they are mated.

In addition, the flange face has a 1½° convex taper which concentrates gasket contact pressure near the bore, reducing the required sealing force. As the bolts are tightened—but long before the bolt moment becomes excessive—the flexible steel flange is deflected toward the cast iron flange to the extent that contact is established over the entire gasket face.

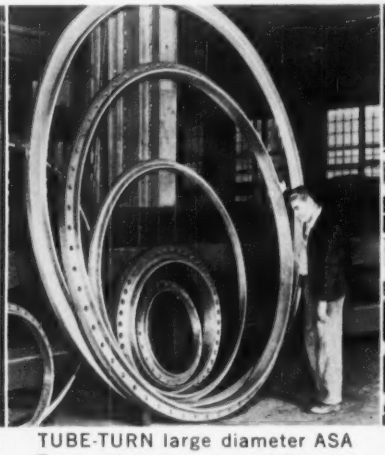
Thus, these features combine two important advantages: (1) A lower sealing force associated with minimum width ring gaskets, located at the bore; and (2) assurance against over-tightening which is characteristic of full face gaskets.

*"TUBE-TURN" and "tt" Reg. U. S. Pat. Off.



There is a complete line of TUBE-TURN Flanges.

Using TUBE-TURN Taper Face Flange on gas distribution line.



TUBE-TURN large diameter ASA Type and pressure vessel flanges.

Your nearby Tube Turns' Distributor provides a complete line of TUBE-TURN Flanges. This one source for all your needs in welding fittings and flanges (more than 12,000 items) enables you to put all your requirements on one order . . . to cut red tape and save purchasing time.

MAIL FOR WALL CHART—New flange matching chart simplifies stocking and procurement. Enables quick selection of correct TUBE-TURN flanges for use with semi-steel lubricated plug valves.

TUBE TURNS
224 East Broadway, Louisville 1, Kentucky

Please send free Flange Matching Chart.

Company Name _____

Company Address _____

Your Name _____

Position _____

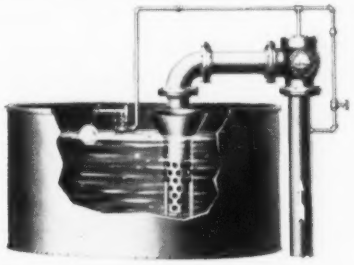
City _____ *Zone* ____ *State* _____

TUBE TURNS

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Chicago • Detroit • Atlanta • New Orleans • Houston • Midland • Dallas • Tulsa • Kansas City • Denver • Los Angeles • San Francisco • Seattle. IN CANADA: Tube Turns of Canada Ltd., Ridgetown, Ontario • Toronto, Ontario • Edmonton, Alberta • Montreal, Quebec • Vancouver, British Columbia.

If you have a
liquid level control problem

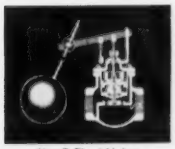


call for a valve from

Klipfel

No matter what type of float valve you want, Klipfel has it. And you can get it quickly. Direct Action and Pilot Control, Single and Double Seated Float Valves are all available to give automatic level control of any liquid in large as well as small installations. Valves of special design, and/or corrosion-resistant materials built promptly.

Call your supply house, or write for Bulletin 254.



No. 7 Float Valve

No. 27 Float Valve

AIR MAIL

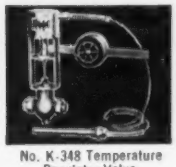
Most items shipped within 24 hours after order is received

No. 410 Reducing Valve

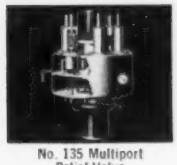
No. 300 Reducing Valve

No. 135 Relief Valve

No. K-449 Temperature Regulator Valve



No. K-348 Temperature Regulator Valve



No. 135 Multiport Relief Valve

HAMILTON • OHIO **Klipfel** VALVES INC.

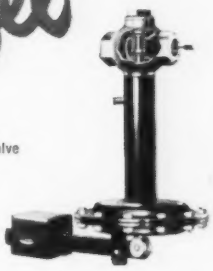
Automatic Temperature-and-Pressure-Regulating Valves Since 1902

Float Valves • Temperature Regulators • Back Pressure Valves • Reducing Valves

A DIVISION OF THE HAMILTON-THOMAS CORPORATION

If you need to reduce fluid pressure safely, economically... call for a valve from

Klipfel



No. 410 Reducing Valve

Klipfel makes Reducing Valves for every purpose—60 different types of them, in fact. They operate on air, gas, steam, water or other liquid, with initial pressures up to 300 psi and reduced pressures as low as vacuum. You can choose from five different inner valves, three different actuating means and four loading means.

Also available from Klipfel are Float Valves, Relief Valves and Temperature Regulator Valves—and special valves made of corrosion-resistant materials. For information on any valve, call your supply house or write for Catalog 54.

Call your supply house, or write for Catalog 54.

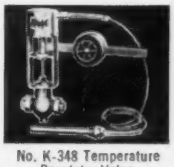
No. 410 Reducing Valve

No. 300 Reducing Valve

AIR MAIL

Most items shipped within 24 hours after order is received

No. K-449 Temperature Regulator Valve



No. K-348 Temperature Regulator Valve

No. 135 Relief Valve

No. 7 Float Valve

No. 27 Float Valve

No. 135 Multiport Relief Valve

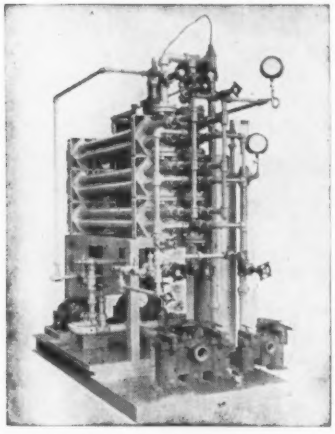
HAMILTON • OHIO **Klipfel** VALVES INC.

Automatic Temperature-and-Pressure-Regulating Valves Since 1902

Float Valves • Temperature Regulators • Back Pressure Valves • Reducing Valves

A DIVISION OF THE HAMILTON-THOMAS CORPORATION

LOCKETT FUEL OIL PUMPING AND HEATING SETS



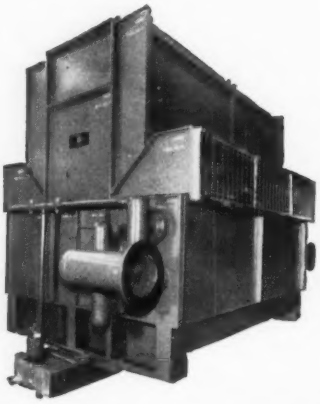
A standard Duplex Pumping and Heating Set, consisting of two Electric-Driven Rotary Pumps, with Griscom-Russell Twin G-Fin Heaters and an Automatic Electric Heater, complete with pressure and temperature controls. Completely piped, wired and tested in our shop.

For more than a half-century, Lockett has been supplying standard and custom-built Fuel Oil Pumping and Heating Sets, for mechanical and steam atomizing oil burners. Various types of pumps are available: Turbine or Motor-Driven Rotary Pumps, Electric-Driven Rotary Pumps, and Duplex Steam Pumps, in any combination. Units can be furnished for any capacity or pressure desired; complete with Strainers, Pressure and Temperature Controls, and Instruments. Each pump is suitable for the full rated capacity of the Unit; one pump and one heater are spares. Engineered to your requirements. Completely assembled and shop-tested. Inquiries are invited. *Descriptive bulletins sent on request.*

A. M. LOCKETT & COMPANY, LTD.

NEW ORLEANS • HOUSTON • DALLAS

ECONOMICAL COOLING OF GASES AND COMPRESSED AIR



Cooling gases or cooling and removing moisture from compressed air, the Niagara *Aero* After Cooler offers the most economical and trustworthy method. Cooling by evaporation in a closed system, it brings the gas or compressed air to a point below the ambient temperature, effectively preventing further condensation of moisture in the air lines. It is a self-contained system, independent of any large cooling water supply, solving the problems of water supply and disposal.

Cooling-water savings and power-cost savings in operation return your equipment costs in less than two years. New sectional design reduces the first cost, saves you much money in freight, installation labor and upkeep. Niagara *Aero* After Cooler systems have proven most successful in large plant power and process installations and in air and gas liquefaction applications.

Write for Descriptive Bulletin 130.

NIAGARA BLOWER COMPANY

Dept. P-6, 405 Lexington Ave., New York 17, N. Y.

Niagara District Engineers in Principal Cities of U. S. and Canada

Appointments

Begins on page 190

Clement F Burnap, technical sales. **Graton & Knight Co, Inc,** Nycor Sales Div: Arnold E Amadon. **Canton Stoker Corp:** Joseph C Fosselman. **Boston Woven Hose & Rubber Co,** Belting Div: George Thorn.

American Water Softener Co, Inc: Robert L Seitz. **Cleaver-Brooks Co,** Industrial Boiler Div: William F Zunker. **De Laval Separator Co,** Precision Equipment Div: Carroll B Hoffman, manager.

District sales manager

Allis-Chalmers Mfg Co: A P Bowman, Milwaukee; R J Dineen, central region. **Boston Woven Hose & Rubber Co:** Carl G Link, eastern region.

Chicago Blower Corp: Donald W Davis, western region. **Riley Stoker Corp:** Harry W Moore Jr, Syracuse. **The Foxboro Co:** John E Hewson, New York. **The Trane Co:** Frank Dalton, San Antonio.

Cooper-Bessemer Corp: Ralph L Reynolds, Grove City; James R Craine, east-central district. **Raybestos-Manhattan Inc:** A N Johnston Jr, central region; H P McLaughlin, Pittsburgh. **American Air Filter Co, Inc:** William Peters, New York City. **The Permutit Co:** J I Munson, northeast; D C Senges, central; H H Morrison, southeast; W H Mitchell, midwest. **Calumet & Hecla, Inc,** Wolverine Tube Div: Neal Hartwell, Wisconsin.

New district offices

Raybestos - Manhattan, Inc: at 6113 Excelsior Blvd, Minneapolis, Minn. **Fisher Governor Co:** in Middletown, Conn. **Burndy Corp:** in Antwerp, Belgium.

New names

Laramore, Douglass and Popham of New York, Inc: New firm name of R R Popham Engineer.

Mason Products, Inc, 317A Main St, West Concord, Mass: new company to design and produce cooling towers.

Rotor Clip Co, 114 Allen Blvd, Farmingdale, L. I., N. Y.: new firm

(*Continued on page* 198)

Hall Industrial Water Report

VOLUME 6 JUNE 1958 NUMBER 3

Steel Production at New High

The day is not too far off when we shall be reading headlines like this. And when we do we shall know that again steel manufacturing facilities are being pushed to the limit and that avoiding unscheduled outages is of paramount importance.

Uninterrupted operation requires an effective water treating program whether the plant is a giant or a midget and whether the product is steel or silk stockings. That is why so many plants retain Hall Laboratories to help them avoid and solve problems with boiler water, cooling water, service water, process water and waste water.

Hard Water in Condensate

When a steel mill installed new boilers the old hot-process, lime-soda softener was retained to treat the make-up water. After a short period, operators were faced with the fact that phosphate consumption was far in excess of what it should have been. Checks showed that the softener was working properly, so hard water had to be entering the system at some other point. But where?

The search for the source of the hard water contamination was finally rewarded with success. In the old power plant, available condensate had been pumped into the raw water inlet line to the softener at a point down stream from the control valve. In the new plant the turbo-blower condensate was pumped into the deaerating heater. The old condensate piping was not removed and was merely extended to the heater. Since less pressure was required to pump the condensate to the new location than to the old, it went to the heater. But along with it went raw water which flowed in reverse through the old condensate piping.

It was easy to eliminate the trouble by blocking the old condensate line after the hard part of tracing down the source had been accomplished by the Hall engineer with the help of the operators.

Cleaner Waste Water

A foundry clarifies hydro-blast water before reusing it or discharging it to waste. Standard procedure was to use aluminum sulfate as the coagulant with activated silica as a coagulant aid. This produced a water of less than satisfactory quality at a high cost.

The Hall engineer substituted a Hagan Coagulant Aid for the activated silica. This not only produced an effluent of greatly improved clarity but did so with almost 75 percent less aluminum sulfate. An added bonus was the ease of preparing the Hagan Coagulant Aid slurry as compared to the care required in mixing the activated silica sol.

"Obvious" Diagnosis Wrong

On a routine visit to an eastern steel fabricating plant, Hall engineer J. T. Waldron found the water in the new high-pressure boiler to be badly contaminated with salt. A check on the zeolite treated make-up water showed this was not the source. Then the condensate from the surface condenser was found to be high in chloride. The obvious conclusion was that the condenser was leaking and allowing contamination of the condensate with the salt water used for cooling.

Waldron had been fooled before and was not ready to accept the obvious answer. He looked further and discovered the real trouble. The low-pressure end of the turbine was sealed with steam through a connection at the top of the seal; at the bottom was a drain connected to an eductor activated by salt water. Insufficient steam was being supplied to the seal, so the vacuum in the turbine outbalanced the vacuum produced by the eductor. Salt water accordingly backed up from the eductor through the steam seal into the turbine. More steam to the seal and a little less salt water to the eductor solved the problem.

Correct diagnosis here was indeed fortunate. If the "obvious" had been accepted the operators would have had an emergency shutdown of the turbine to check the surface condenser. Then they would have been dismayed to find no leaks and no answer to their difficulty.

Steel Without Spots

The galvanized strip steel from a Pennsylvania mill developed large discolored spots some weeks after shipment. Because of their concern over this serious problem the operating men enlisted the aid of everyone who might be able to help them.

Hall Engineer B. Q. Welder was asked for his opinion. From his experience with metal cleaning, he suspected the rinsing operations. Following galvanizing the strip was spray rinsed with filtered river water, dip rinsed with the same water and then rinsed in a sodium chromate-sodium silicate solution prepared with river water. Welder's opinion was that the solids in the rinse waters were drying on the metal. When a humid atmosphere subsequently produced condensation and solution of the salts, they reacted with the zinc coating, discoloring the metal surface. A confirming factor was the increase in seriousness of the spotting in inverse ratio to the gauge of the strip. Lighter gauge material traveled faster through the equipment and carried out more water.

A condensate rinse was added just ahead of the chromate-silicate rinse and condensate was substituted for river water in preparing the latter solution. The problem was solved.

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information on how the Hall System can help you solve your particular water problems, write, wire or call address below.

Water is your industry's most important raw material. Use it wisely.

HALL LABORATORIES

DIVISION OF HAGAN CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY; HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED—TORONTO

Hall Laboratories—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water

H-W PLASTIC REFRACTORIES

make durable, efficient and economical

BOILER FURNACE SETTINGS

Harbison-Walker Plastic Refractories comprise all the kinds best adapted for the many different operating conditions. They form solid, joint-free linings including arches and bridge walls having physical properties closely similar to the corresponding classes of refractory brick.

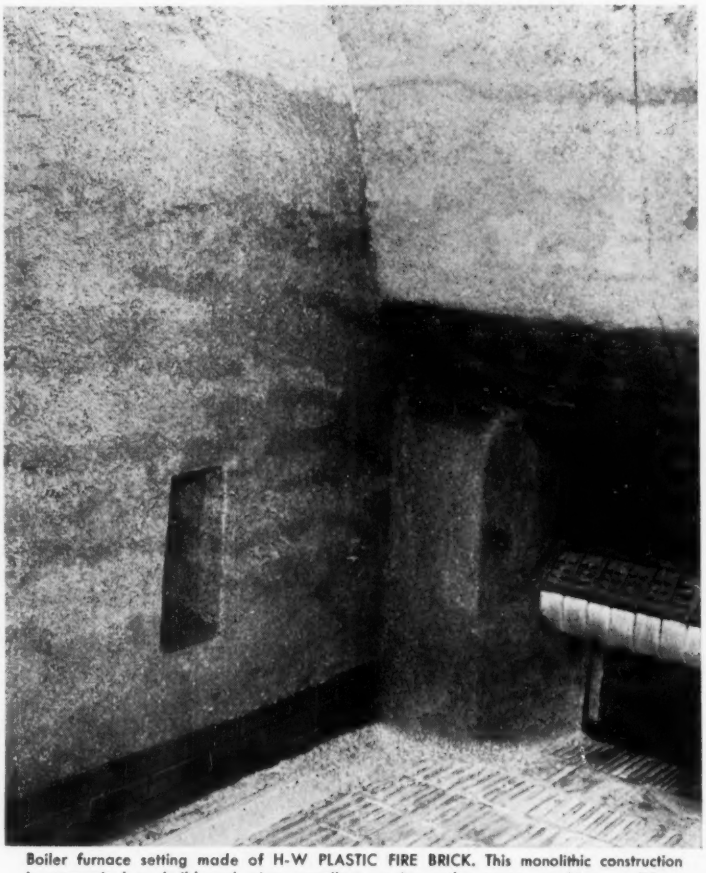
H-W STANDARD PLASTIC FIRE BRICK is a dense-burning, uniform refractory made of the same clean, high purity flint clay of hard burn and plastic bond clay as are used in the best high duty fireclay brick.

H-W SUPER PLASTIC FIRE BRICK possesses the properties of super-duty fireclay refractories and is used economically in applications where temperatures exceed the limits for **H-W STANDARD PLASTIC FIRE BRICK.**

H-W SUPER PLASTIC CS takes a cold-set after drying in the low temperature range. This added strength prior to the development of the usual strong ceramic set is especially desirable for certain furnace installations.

APACHE PLASTIC FIRE BRICK is the high-alumina plastic refractory which withstands the highest temperatures to best advantage and is most resistant to chemical attack by corrosive slags.

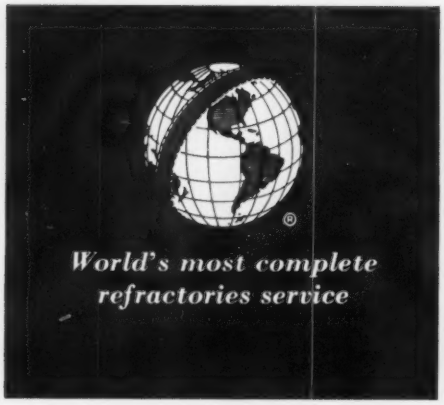
Write for complete information about these leading Harbison-Walker plastic fire brick.

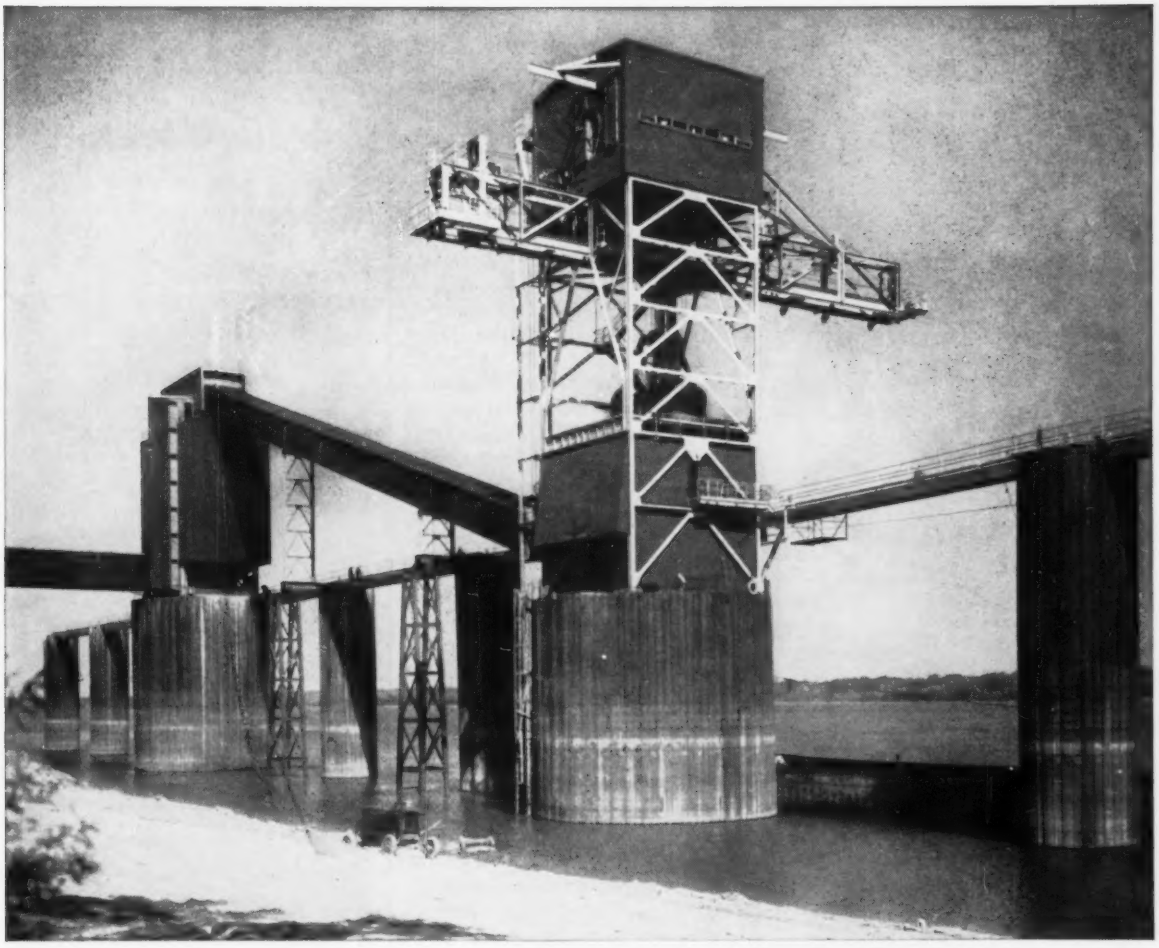


Boiler furnace setting made of H-W PLASTIC FIRE BRICK. This monolithic construction is economical to build and gives excellent service under severe working conditions.

HARBISON-WALKER REFRACTORIES COMPANY AND SUBSIDIARIES

General Offices: Pittsburgh 22, Pennsylvania





9-ton coal unloader, with free digging capacity of 850 tons per hour, has an average operating lift of 75 feet and travel distance of 40 feet.

Barge unloading?...WE DO THE COMPLETE JOB— unloading tower, dock and all auxiliaries

Dravo experience in the design and construction of complete bulk materials handling installations can help you lower coal handling costs materially. Take the facility shown above. The cellular steel sheet pile dock requires no maintenance, provides safe mooring for barges and supports the barge shifters, other auxiliaries and the unloading tower.

This all-welded tower has a single hoist motor and drum which perform all hoisting and lowering operations. Hoisting rope pull is equalized, and a counterweight reduces hoisting horsepower. A separate drive provides independent and positive bucket closing.

Dravo facilities provide for the design, fabrication and erection of the complete job. Tower, dock and auxiliaries are integrated into a smooth-running installation designed to operate at maximum efficiency and low cost.

Dravo heavy materials handling equipment is at work in power plants, steel mills, port docks and other materials transfer points. You can learn about Dravo's complete line of trolleys, bridges, towers and other related equipment by writing for Bulletin #225. Better still, let us arrange for your visit to actual installations. Simply call us at Pittsburgh, Spalding 1-1200, or write DRAVO CORPORATION, PITTSBURGH 25, PENNSYLVANIA.

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Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

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This Yarway team has scored high—over a million installed on all types of steam equipment. Stocked and sold by 270 Industrial Distributors. For free Steam Trap Book, write YARNALL-WARING CO., 100 Mermaid Ave., Philadelphia 18, Pa.

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Appointments

Begins on page 190

to produce industrial retaining rings. **Jaeco Pump Co,** Vallanova, Pa: a new reciprocating-pump company. **Midwest Airmoving Corp,** 4498 Beidler Rd, Willoughby, Ohio: ventilation equipment manufacturing.

Recent purchases, mergers:

United Electric Controls Co: a new subsidiary, Aerotech Specialties, Inc. **Waukesha Motor Co:** purchase of assets of the engine business of Le Roi Div, Westinghouse Air Brake Co.

Aluminum Co of America: purchase of transformer div of Automation Instruments, Inc. **Lovejoy Flexible Coupling Co:** controlling interest in Hi-Lo Mfg Co.

Retirements

R B Werey, president of Conoflow Corp. **Thomas E Hurns,** vice-president of Detroit Edison Co, after 49 years. **Claire H Fellows,** director of Detroit Edison Co's engineering lab and research dept, after 38 years.

Percy E Cook, consulting engineer at Allis-Chalmers Mfg Co's Pittsburgh Works, after 25 years. **John Horn,** consultant, General Electric Co, after 39 years. **William L Hunter,** vice-president and general manager of Blaw-Knox Co, Copes-Vulcan Div, after 30 years. **G Rodger Sturtevant,** engineering manager of the General Electric Co's Meter Dept, after 34 years.

Obituaries

Carman R Acker, president of the Acker Corp, on April 4th.

Fred O Reedy, president of Kennedy Van Saun Manufacturing & Engineering Corp, on February 24th.

Austin L Hawk, 47, sales executive of Manhattan Rubber Div of Raybestos-Manhattan, Inc, on March 21.

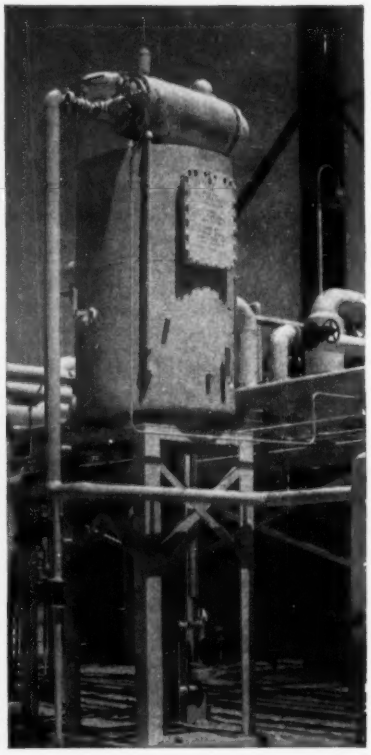
Fred R McCormick, 45, chief engineer of power-plant construction for Idaho Power Co, on March 24th.

Osborn H Cilley, 75, vice-president and director of Raybestos-Manhattan Inc, on April 15th.

George Vincent Slottman, 54, vice-president of Air Reduction Co, Inc, on April 21st.

Hamilton Garnsey Jr, 56, vice-president and general manager of Goulds Pumps, Inc, on April 26th.

How to solve a feed water problem

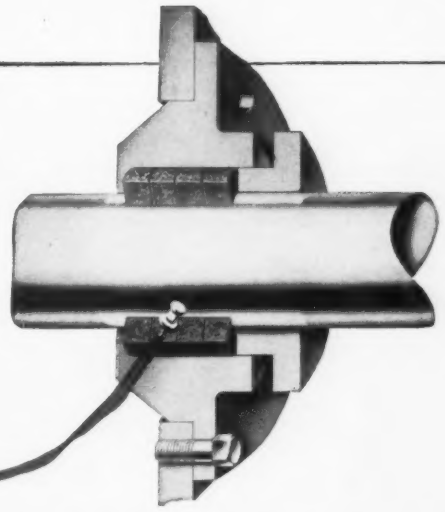


A Texas oil refinery needed a packaged feed water heater rugged enough for exterior installation, and capable of delivering water at specified temperature even with 1" or more of encrustation on tray surfaces. Selected for the job was the Stickle unit shown above. Extra deep trays force water to flow irregularly in a thin film, depositing solids and releasing noncondensable gases. Trays cannot overflow; are easily removed for cleaning. Open coils bring feed water into direct contact with steam, immediately transmit heat to water. Condensed steam is not wasted. It provides one-sixth of boiler feed supply. There's a Stickle feed water heater for practically every need. Capacities 3,000 to 300,000 lbs. per hr. Stickle has built heaters since 1905; is well equipped to solve your feed water problem. Write for free bulletins.

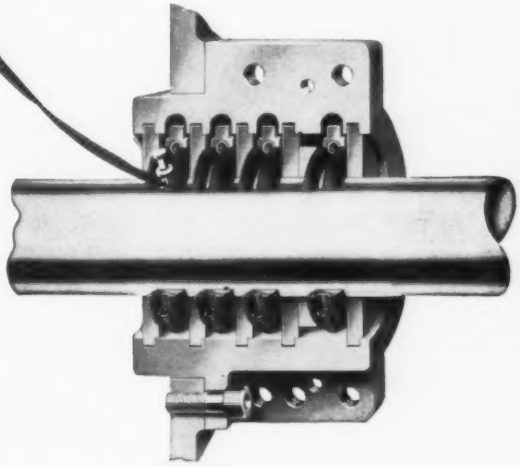
STICKLE STEAM SPECIALTIES CO.
2265 Valley Ave. • Indianapolis 18, Ind.

COPPUS TURBINES

offer you a choice of packing rings



STANDARD METALLIC RING PACKING — Made of high grade asbestos cores encased in specially treated lubricated aluminum foil. Recommended as a low-friction, long-service packing for steam temperatures up to 850 F and back pressures up to 50 lb. Adjustable packing glands keep leakage at minimum. Easy access to packing rings.



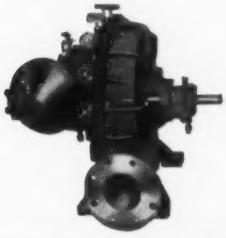
OPTIONAL CARBON RING PACKING — Consists of three carbon packing rings on the pressure side and one beyond the leak-off section. Each ring has three segments held together by a stainless steel garter spring. For back pressures up to 75 lb. Standard for vacuum or gas operation, or when leak-off is desired.

Heavy chrome plating on shaft at stuffing box is common to both types of Coppus packing.

Coppus Turbines ranging from 150 hp down to fractional in 6 frame sizes

FIT TURBINE COSTS TO HORSEPOWER NEEDS

When you buy turbines rated close to your exact horsepower needs, you save plenty of money. That's because turbines are generally priced in proportion to their size. The wide range of sizes of Coppus Turbines promises purchasing economy for you from the 150 hp size down to the smallest. As for operating and maintenance economies, you get them, too, from such other features as: greater number of manually operated valves for individual control of steam nozzles; replaceable cartridge-type bearing housings and others. For complete details . . .



WRITE FOR BULLETIN 135
COPPUS ENGINEERING CORPORATION
166 Park Avenue
Worcester 2, Mass.
Sales offices in THOMAS' REGISTER

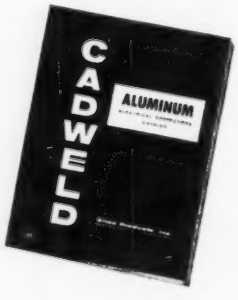
COPPUS "BLUE RIBBON" TURBINES

LATEST NEWS in the electrical industry is ERICO PRODUCTS, INC.'s new thermit type welded aluminum connection. Similar to their copper CADWELD PROCESS, NEW connections can be made on aluminum cable to: cable, lug, bus, surface or tube; bus to bus and bus to lug or tube. Also available are transition joints of aluminum to copper.

The new CADWELD Aluminum Process is a controlled exothermic reaction — a reduction of tin oxide by aluminum forming a tin-aluminum alloy. The reaction takes place in a machined graphite block, housing the aluminum conductors to be welded. The reaction produces molten metal which flows over the aluminum (or aluminum to copper) conductors fusing them into a solid homogeneous mass.

Outside laboratory tests have proved the connections to be excellent electrically and good physically. Tensile strength is equal to that of the annealed conductor. Extreme portability of equipment (requiring no outside source of power or heat) gives the customer the Number One aluminum electrical connection that does not loosen or corrode.

New catalog gives technical, instructional and ordering information on over 30 basic type connections. With the growing acceptance of aluminum as an electrical conductor, CADWELD ALUMINUM CONNECTIONS now solve the most difficult problem —a high quality electrical connection.



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Erico Products, Inc.

2070 E. 61st Place Cleveland 3, Ohio

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Reports from the field

Begins on page 146

tion unit which it believes to be unique, and shooting for new clients throughout the process industries.

In their setup, designers, procurement specialists and construction men make all decisions on the basis of total plant cost, ignoring the usually all-important departmental balance sheets.

Costs are further cut by new techniques: three-dimensional plastic models to reduce paper-work (see POWER, May 1958, p 144) and the use of computers to make tedious design calculations, a development which should free engineers for creative thinking.

An upsurge in industrial plant and equipment expenditures in the near future is forecast by C B Wigton, president of the Wigton-Abbott firm of engineers and constructors. He bases his prediction on increased research expenditure, the need to lower production costs, increasing obsolescence of present plants, easier financing and the possibility of further inflation. The introduction of automation, for example, necessitates new plant designs and locations for best efficiency and lowered costs in the long-range picture.

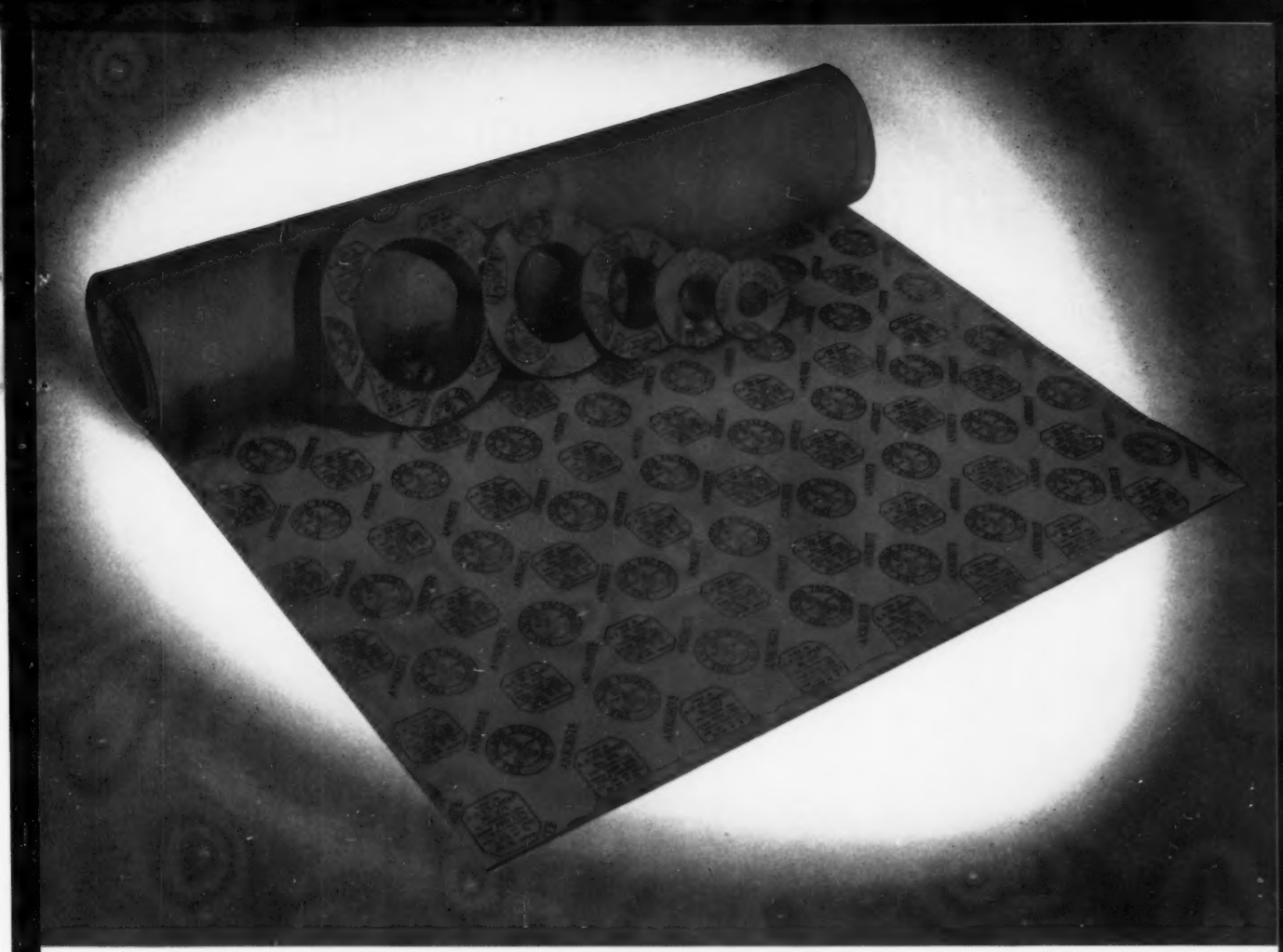
Further cost cutting can be accomplished by planning steam and electric systems together, according to the General Electric Co's engineers. Step-by-step performance analyses for new, expanded or modernized plants can show how to save good sums of money on fuel and electricity bills.

Will these ideas lick the recession? And how soon can we bury Mr Gloom? Only time can tell for sure, but, as Kellogg's J M McAneny says, anything which may induce a man to take the rubber band off his bankroll is grist for the mills.

Our Latin neighbors to get automatic gas-turbine plant

First gas-turbine power station with completely automatic remote controls will be built for Compania Shell de Venezuela to power a $85-million oil-storage and tanker-loading facility on Lake Maracaibo.

The 10,000-kw station, located on lake's eastern shore opposite the city of Maracaibo will be constructed and equipped by Westinghouse Electric



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With more than fifty years experience in the design and manufacture of mechanical packings, The Anchor Packing Company is constantly searching for new materials and fabrication techniques that result in more efficient and longer lasting products for industry.

Striking "by-product" of this continuing research is the Ankorite Green Label rubber stock presented here. *This is the finest rubber gasket sheet yet to be made.* Designed to give unmatched service in steam, air or hot water applications at temperatures up to 350 degrees, Ankorite Green Label Red Sheet is carefully compounded to insure maximum strength and resistance to aging. It is tough and resilient—yet can be accurately cut to size and shape.

For further information on Green Label Red Sheet or other Anchor products, see your local Anchor Representative. He will gladly assist you. Or, contact the Anchor General Office in Philadelphia.

THE ANCHOR PACKING CO.

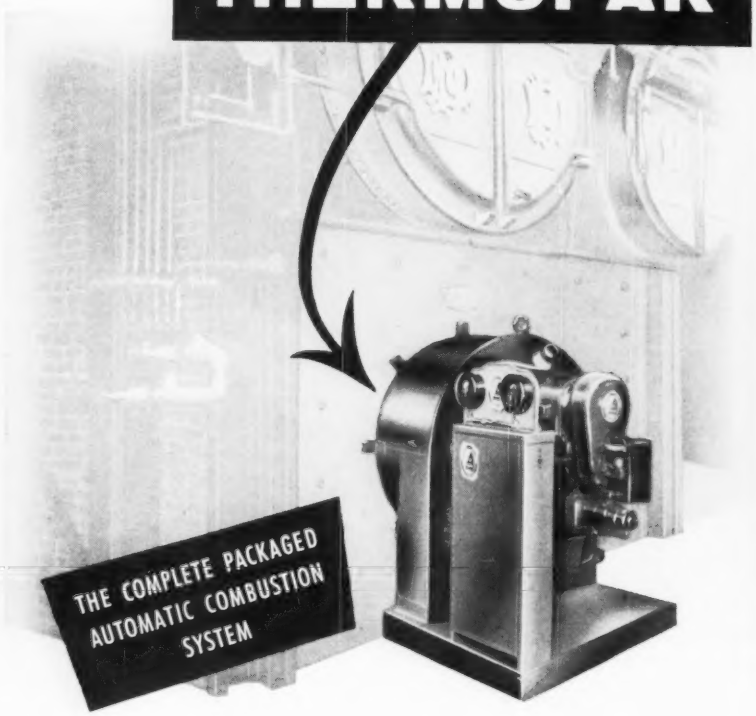
THE ANCHOR PACKING COMPANY

GENERAL OFFICES . . . PHILADELPHIA, PENNSYLVANIA
FACTORIES . . . MANHEIM, PA., ELKHART, IND., MONTREAL, CAN.

FIBROUS AND METALLIC PACKINGS FOR EVERY INDUSTRIAL PURPOSE

BRING YOUR BOILERS UP TO PEAK EFFICIENCY *Now*

with **THERMOPAK**



Existing low efficiency, high maintenance boiler plants can be redesigned to approach the performance of modern "package" boilers through the installation of the "Thermopak" system.

The higher heat release of the burner nozzle, coupled with preheated secondary air, will improve combustion efficiencies as much as 20 per cent at all firing rates. This design simplifies internal refractory construction and extends the life of that refractory to 2 to 3 times normal. These advantages in effect assure lower fuel and maintenance costs.

The "Thermopak" costs the least to install: eliminates complicated on-the-job wiring, fuel piping, refractory construction and fitting to the boiler. It is a factory-assembled, fully automatic combustion system for oil, gas or combustion fuels—ready to install in any water-tube, HRT, Scotch Marine or cast iron boiler of 20 to 1000 HP.

Most important—your investment in "Thermopak" means single Preferred responsibility for engineering, erection and instruction in proper operation.

Learn more about the "Thermopak" plan for improving your boilers. Write for Bulletin 185A.

PREFERRED UTILITIES MFG. CORP.

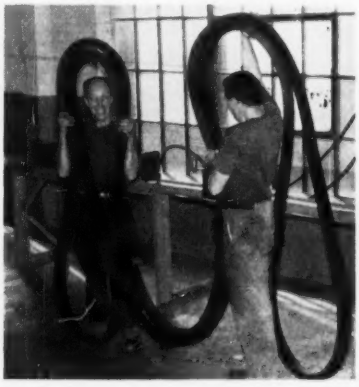
1860 BROADWAY NEW YORK 23, N. Y.

Reports from the field

Begins on page 146

International Co. Capacity will allow initial handling of 700,000 barrels daily, eventually over one million barrels a day.

Automatic remote controls will let one man run turbine and distribution system from a single control room. The two 5000-kw gas turbines are designed to switch from gas to diesel fuel. Station is slated to begin operation this October.



Giant aquatic V-belts will soon be under water

Three giant V-belts, each weighing 140 lb, are among the largest ever made. Over 57-ft long, the belts are 3½-in. wide, 1.62-in. deep.

Belts will be used under water to turn large wheels geared to paddle agitators in flocculator basins, where chemicals are added to precipitate-suspended impurities in the water. They are designed to turn at 1.44 rpm, 24 hours a day, for years on end.

The V-belts were made by Gates Rubber Co for the St Louis Water Co, to replace earlier models which have been in service for 17 years.

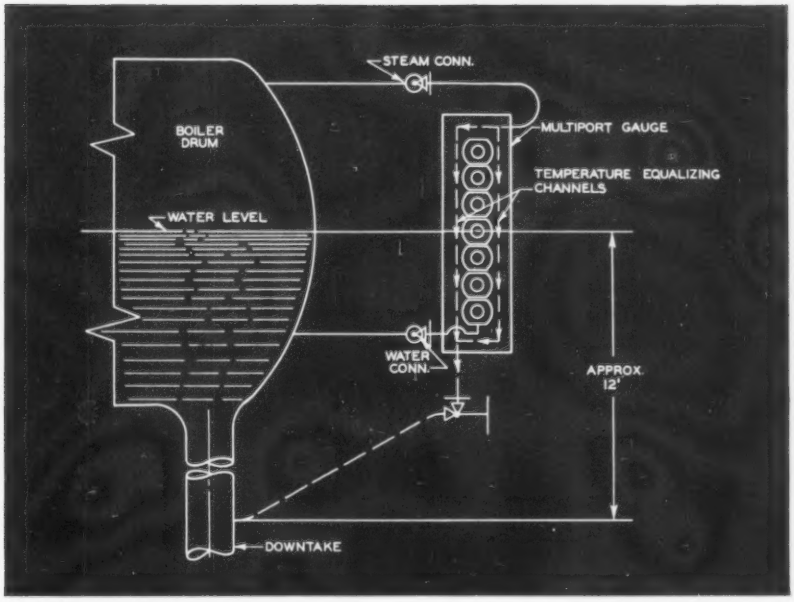
Calendar of Events

June 9-12—Edison Electric Institute, Annual Convention. Boston, Mass.

June 9-13—Oil-Heat Institute of America, Inc, convention and exposition. New York City, N. Y.

June 9-12—American Society of Mechanical Engineers, Materials

ANOTHER NEW GAUGE DEVELOPMENT BY Diamond



Diagramatic illustration of new Diamond Temperature-Equalizing Multi-Port Gauge installation.

The need for correction of inherent gauge error at high operating pressures is well recognized, but heretofore no satisfactory simple answer has been found. Now, Diamond has developed the Temperature-Equalizing Multi-Port Gauge* to reduce the error in gauge level reading by a simple and fully reliable means.

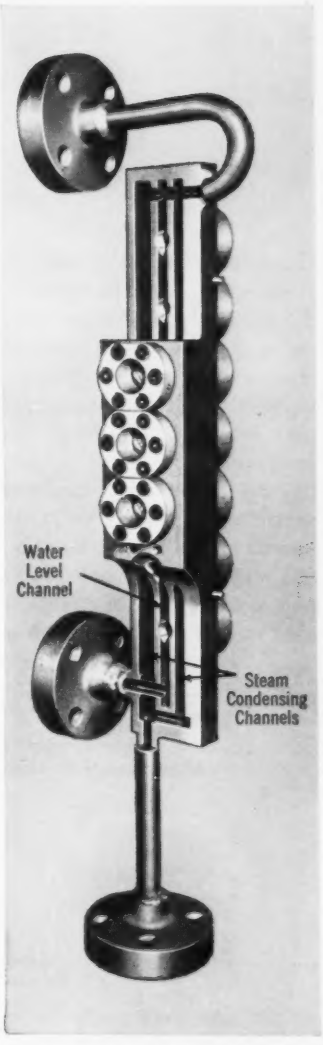
Gauge error (resulting from the gauge temperature being lower than boiler saturation temperature) is substantially avoided by introducing supplementary gauge heating in the form of steam condensing channels. These channels are parallel to the gauge water level channel as illustrated, and serve to heat the gauge level channel by direct conduction of heat from condensing steam through the gauge body itself. No external source of energy or control is required. The heating channels have a natural circulation system independent of the gauge level channel so that no faulty operation can occur under any circumstance.

Ask your local Diamond office or write directly to Lancaster, Ohio for Form 2150 for further information.

*Patent Applied For

8031

DIAMOND POWER SPECIALTY CORP.
LANCASTER, OHIO
DIAMOND SPECIALTY LIMITED—Windsor, Ontario



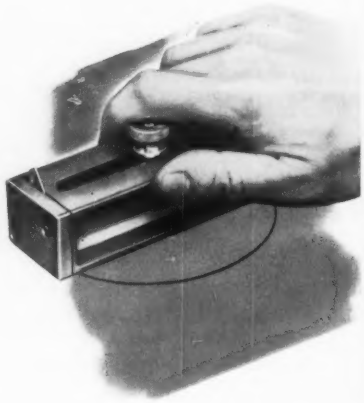
Cut-away sections illustrate independent gauge body heating channels of the new Diamond Temperature-Equalizing Multi-Port Gauge.

You can DO IT YOURSELF in minutes...

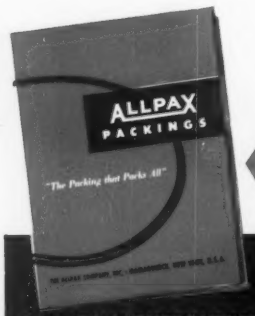
with the ALLPAX Gasket Cutter

Maintenance men from Maine to Mexico have found that they can save hours of costly "down time" with this handy kit. Accurate gaskets can be cut quickly and easily by following a few simple directions—as easily as drawing circles with a compass.

The Allpax Gasket Cutter uses the "ironing principle" to hold material flat during the sweep of the cut, and prevents buckling and tearing common with make-shift devices. All materials in general use as gaskets may be cut to diameters ranging from ¼" to 36" using the popular No. 3 kit. Other kits available for maximum diameters of 12, 24, 48 and 60 inches. Allpax Gasket Cutters and accessory tools are neatly packaged in the permanent metal tool case shown above. An 18" square cutting board is supplied with each kit.



See your local dealer for additional information on the Allpax gasket cutter and our complete line of gasket materials.



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Reports from the field

Begins on page 146

Handling Conference in conjunction with National Materials Handling Exposition. Public Auditorium. Cleveland, Ohio. Details from ASME, 29 W 39th St, New York 18, N. Y.

June 9-13—Fourth International Automation Exposition. The Coliseum, New York City, N. Y. Details from Richard Rimbach Asso, Management, 845 Ridge Ave, Pittsburgh 12, Pa.

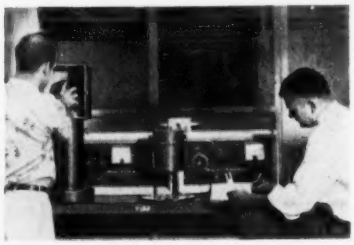
June 15-19 — American Society of Mechanical Engineers, Semi-Annual Meeting. Hotel Statler, Detroit, Mich. Details: ASME, 29 W 39th St, New York 18, N. Y.

June 22-27 — American Society for Testing Materials, 61st Annual Convention. Statler and Sheraton-Plaza Hotels, Boston. Details from Val Laughner Asso, 755 Boylston St, Boston 16, Mass.

June 22-27—American Institute of Chemical Engineers, 50th Anniversary meeting. Philadelphia, Pa. Details: Joseph I Savoca, Socony Mobil Oil Co, Paulsboro, N. J.

June 23-25 — American Society of Heating and Air-Conditioning Engineers, Inc, and **American Society of Refrigerating Engineers.** Leamington Hotel, Minneapolis, Minn.

August 18-21 — American Institute of Chemical Engineers, Heat-transfer Conference. Northwestern University, Evanston, Ill.



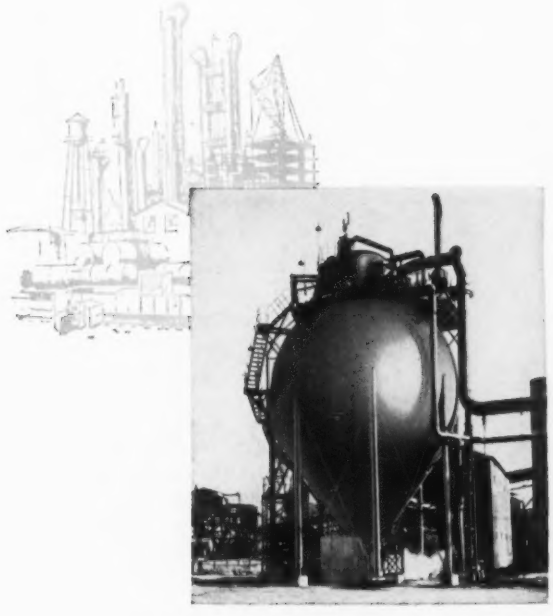
Leak-detection unit handles quantity work

Technicians shown are recording leak rates as registered on a leak-detection

First in water conditioning

Cochrane HOT PROCESS

AT U.S. STEEL'S CLAIRTON PLANT



Designed to soften and deaerate 100,000 GPH of boiler feed water, this Cochrane unit at U.S. Steel's plant is a sludge blanket design deaerating type Hot Process Softener with a 38' dia. spherical top sedimentation tank. The Softener is followed by six 11' dia. anthracite filters equipped with surface washers.

Cochrane pioneered the versatile Hot Process Softener. Its flexibility and efficiency are unquestioned and it provides a water softening process that can handle both turbid surface supplies and clear well waters.

Cochrane Hot Process Softeners can be used to reduce silica economically and effectively. It is also possible to provide integral deaeration elements for condensate and treated makeup where required.

For medium and high pressure boilers, Hot Process can be followed by Hot Zeolite to provide zero hardness and lower solids as well as to reduce CO_2 in the steam.

If you now have a Hot Process Softener, Cochrane Hot Zeolite may be readily added, assuring higher effluent quality at lower treating cost.

Cochrane, first in water conditioning for over half a century, continues to lead the way in Hot Process and Hot Zeolite. Call our engineers for the answer to your problem. Ask for Publication 4801.

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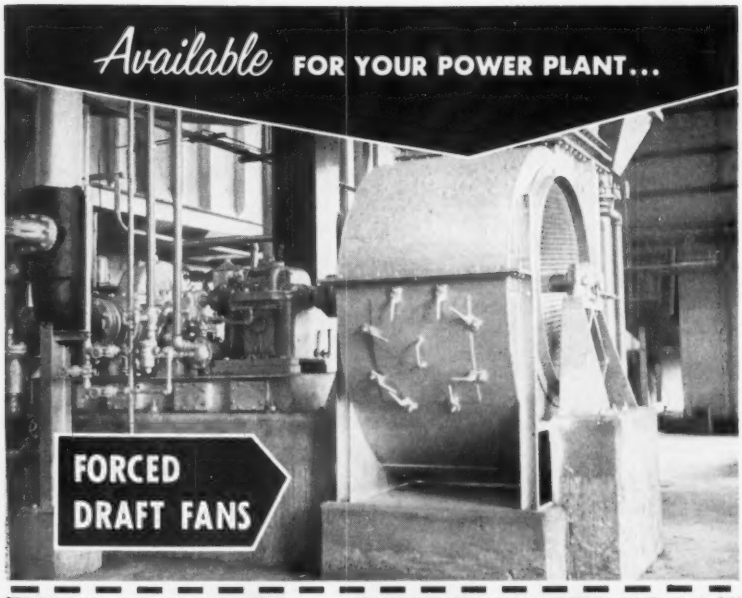

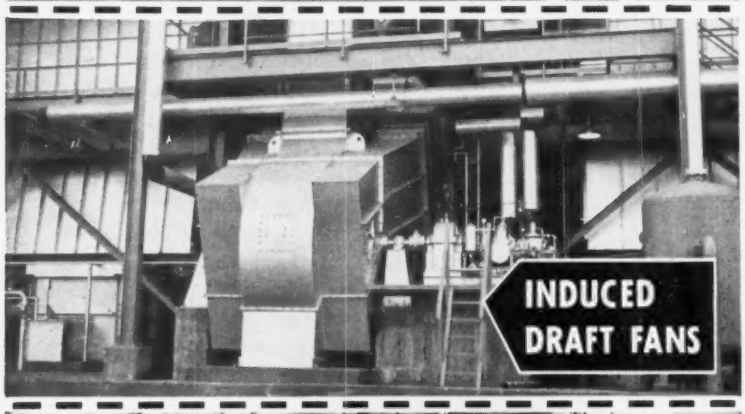

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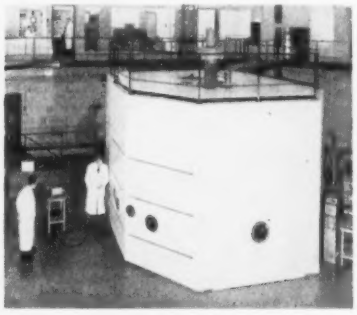
Reports from the field

Begins on page 146

unit. Unit can trace leaks of 10^{-13} cc per sec, a rate so minute that it would take five million years for one cubic inch of air at atmospheric pressure to leak into an evacuated vessel.

Process, which utilizes a non-toxic radioactive gas, Radene III, is for control and testing of hermetically sealed components. It was developed by American Electronics, Inc, and is reportedly suitable for "mass-production" testing.



A 50-kw German reactor goes into operation

West German scientists, above, are conducting radiation measurements at an exposure port of their new "solution type" reactor. Unit uses enriched U-235 in a water solution as fuel.

Reactor is installed at the Max Planck Institute for Nuclear Physics of the University of Frankfurt in West Germany. It was built by the Atomics International div of North American Aviation, Inc.

Mobile 15,000-kva substation may be world's largest

Possibly the highest-rated mobile electrical equipment ever made will be used to speed complete substation facilities wherever they are needed for emergency or maintenance service. Built for a southwestern utility, the substation will also be used as a replacement unit when permanent facilities are altered.

The 15,000-kva "Transmobile" meets all normal highway clearances. It consists of a transformer with a circuit breaker, lightning arresters and high-voltage fuses, and has a primary voltage of 64,000 v. The unit was built by Pennsylvania Transformer Div of McGraw-Edison Co.

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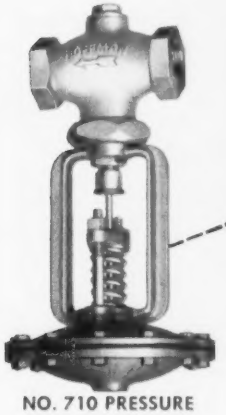
To protect valves, traps and pumps from damage caused by dirt, rust and scale. For use on steam, water, oil or gas service.



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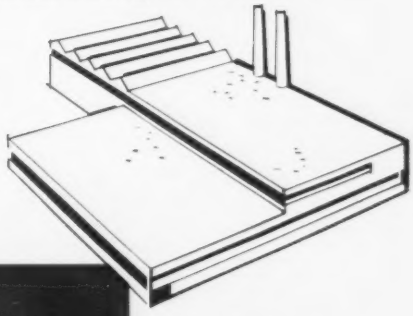

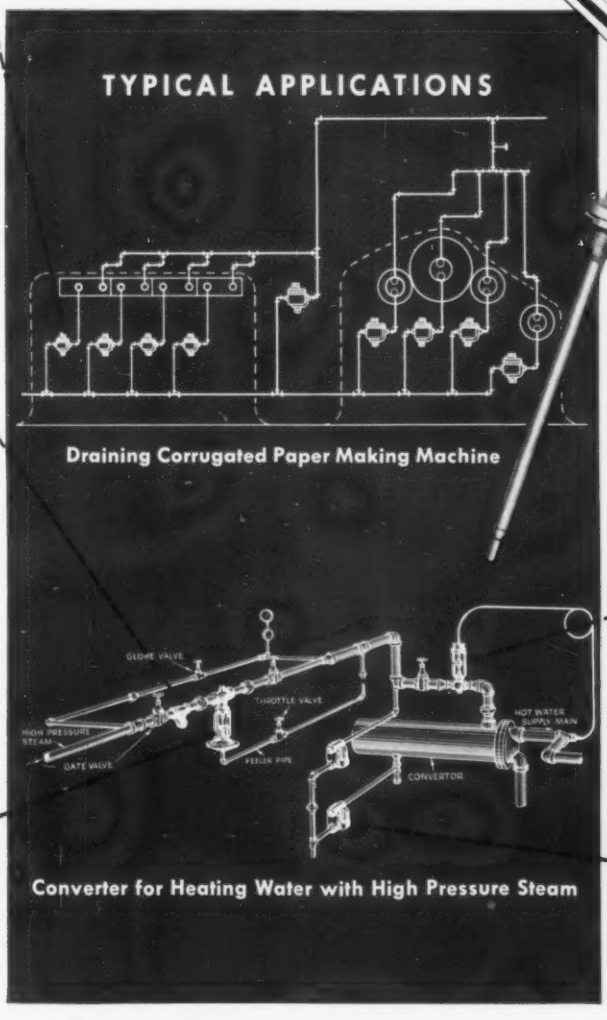

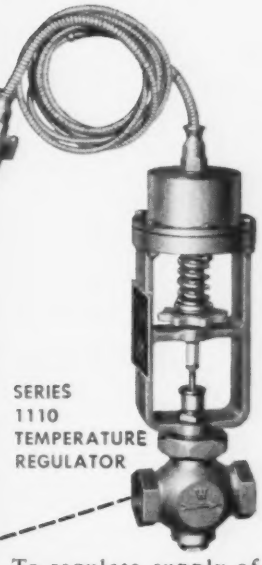

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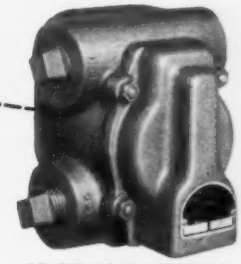

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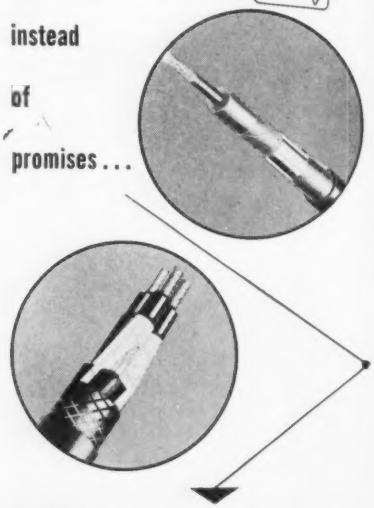

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Welding

Continued from page 111

that rolling produces rather significant stress levels. It lengthens these tubes, putting them under compression. This in turn puts the unrolled tubes under tension. So if all tubes are rolled it's likely they will be under compression. Magnitude of the stress depends upon combined effects of tube and tube-sheet flexibility. There's a good chance that the amount of compression will be less than given in the stress table. Just as in our tests, unrolled tubes will act as stays to produce a stiffening effect on tube sheets.

If no tubes are rolled, which is the case for data under peening, tubes will generally be in tension because of tube contraction as the welds cool. Amount of this stress depends largely on tube-sheet flexibility since there is little longitudinal movement of the tubes under tension. Since stress corrosion usually goes with tension and rarely with compression, it's wise to roll the tubes into the tube sheets after welding. This is important when stress corrosion is anticipated.

Cyclic stress. The next step subjected the simulated heat exchangers to cyclic stress. Figure 4 shows the cumulative percent of failures at the joint with welded but unrolled tubes. First failure in Part A happened after 90,000 cycles. First failure in Part B took place after 330,000 cycles. By the time 330,000 cycles were reached in both simulated heat exchangers (Parts A and B) 19% of the unrolled tubes failed. Rate of failure, once failure occurred, was much more rapid for test frame in Part B than in Part A.

Initial tension stresses in these unrolled tubes are low and in the same order of magnitude. So it's hard to relate them to differences in rate of failure for the two heat exchangers. Failure comes so early in terms of total number of cycles making up an acceptable life that the rate-of-failure difference here isn't large enough to have any real meaning.

Most important conclusion from this part of the test is that even though there is a difference in stress resistance between the two welding-without-rolling methods, neither is satisfactory. In a matter of hours, with a relatively small number of cycles and low vibration amplitude

(Continued on page 212)

McDonnell Answer ... for boilers up to 150 psi

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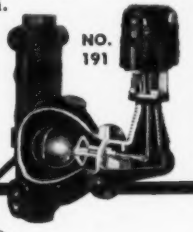

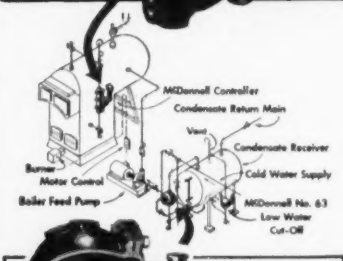

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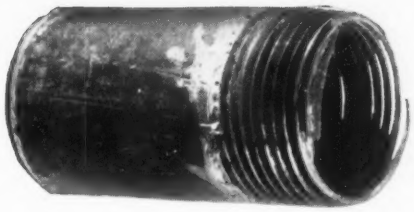

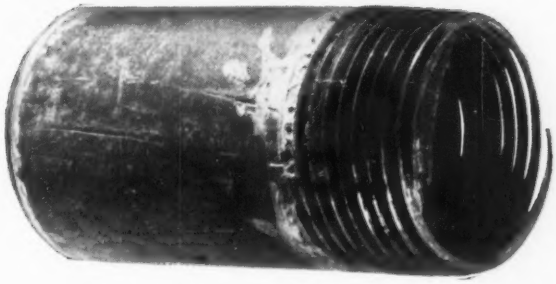

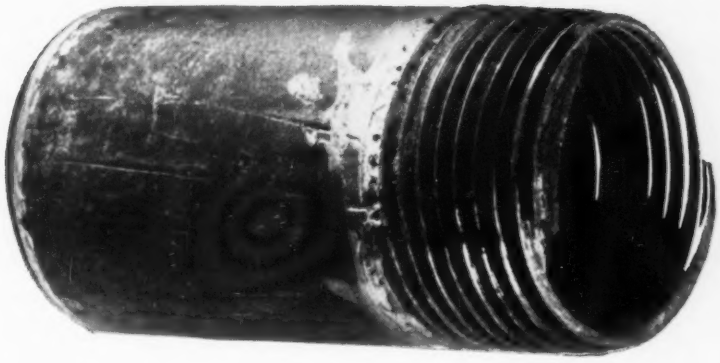

● *Unretouched photos showing carbonic acid destruction typical of untreated pipelines.*

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It's too late for water treatment after the damage is done. Replacement of these threadbare nipples in the return line was only a matter of time. The grooving-type corrosive action of carbonic acid took care of that.

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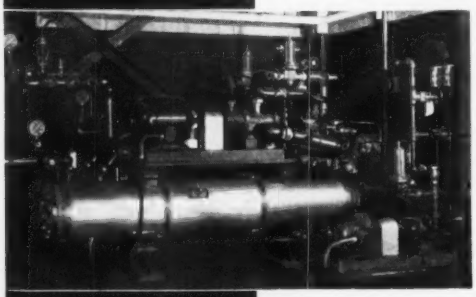

Heaters are insulated and jacketed with removable heads at both ends for cleaning without breaking any piping connections or removing any tube bundles.

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Welding

Continued from page 208

(about 3/16 in.), a significant amount of failure takes place. And it's not hard to develop amplitudes of this order in a surface condenser at certain loads and temperatures.

Tubes that are welded and rolled show no failure at 10-million cycles in both exchangers with the same vibration amplitude used for the welded-only tubes. Tests on the heat exchanger in Part B extend to over 18-million cycles without failure. Both the 10-million and 18-million values, considering the number of samples tested, indicate indefinite life can be expected.

Failures with unrolled tubes generally start in the weld directly in line with the notch formed at the root of the weld. As the structure continues to vibrate, a second fracture line usually develops. This one runs circumferentially around the tube adjacent to the weld. We believe these weld failures are caused by the almost perfect notch formed between the tube and tube sheet at the weld root. This is apparent in the photomicrographs shown in Figure 2. A stress-raising effect two to three times calculated stress doesn't seem too excessive an estimate.

Rolling tubes into the tube sheets will shield the welded joint from any stress normally produced by tube vibration. The rolling used is substantially standard practice for rolled-only tubes. We believe this step is necessary in actual field installations to prevent cyclic stress failure in welded tube ends.

Metallography. Before completing all mechanical tests, welded joints were selected from Sections II and III tube-to-tube-sheet assemblies and cut to give metallurgical sections. These show weld quality and penetration in all of the material combinations, and let us compare manual- and machine-welded joints. Individual joints for sectioning are taken at random from the assemblies. Each section is mounted, polished and etched with an ammonia-hydrogen peroxide solution.

Photomicrographs in Figure 2 are taken at 12 diameters and identified by test assembly.

Cross sections from Section II are typical of welds between admiralty-metal tubes and copper-silicon tube

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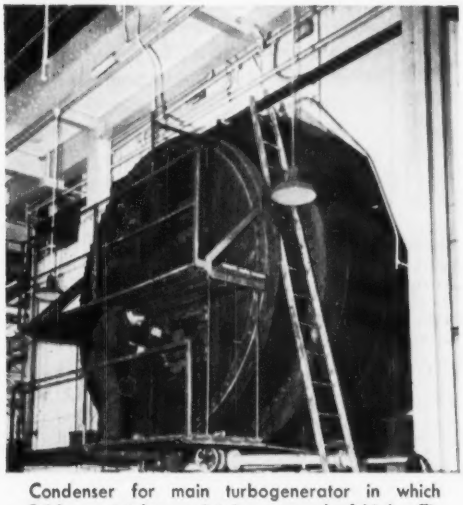

Condenser for main turbogenerator in which Bridgeport tubes maintain a record of high efficiency and long life.

This steam condenser tube record at a New England utility isn't often equaled. The 25,000 sq. ft. condenser in this plant contains 4,340 18-gauge Bridgeport Aluminum Brass tubes, each 22 ft. by 2 7/32 in. In 17 years of operation only five tubes have had to be replaced.

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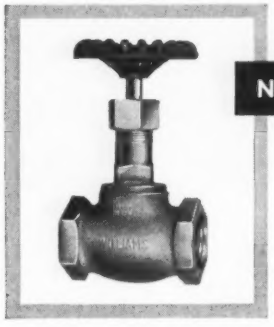

No. 50 Bronze Globe Valve—Bronze Disc. This valve has an integral seat, deep stuffing box, molded ring packing and screw ends. Swivel disc is provided on ¾" and larger sizes. Steam pressures to 125 lbs. and non-shock water, oil or gas to 200 lbs., at 150° F. Available in sizes ⅛" to 3".

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No. 55 Bronze Angle Valve—Bronze Disc. Has an integral seat, deep stuffing box, molded ring packing and screw ends. Swivel disc is provided on ¾" and larger sizes. Steam pressures to 125 lbs. and non-shock water, oil or gas to 200 lbs., at 150° F. Sizes ⅛" to 3".

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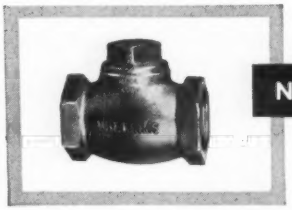

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Welding

Continued from page 212

sheets. Lower amperage used for manual welding in Sections IIA and C gives comparatively less weld penetration. Part C had the same welding current. But an increase of 1½ sec in welding time probably accounts for slightly deeper weld penetration.

Weld cross sections from IIB and D clearly show the greater penetration obtained with automatic-welding equipment. Difference in weld contour is typical of cross sections taken from portions of the weld where welding direction is vertical upward (Part B) and vertical downward (Part D).

Cross section of weld between aluminum-brass tube and copper-silicon tube sheet (Section IIIA) is typical of weld contours made with this combination of materials. Note distinct ripple on the weld surface.

Admiralty-metal tube and naval-brass tube-sheet (Sections IIIF and H) weld cross section distinctly shows loss of penetration in Part H from lower amperage. This came about because both argon and helium were used for shielding gas.

Aluminum-brass tube and naval-brass tube-sheet combination (Section IIIG) shows reduced penetration. (Joint design used is shown in Part I, Figure 6, page 97, March POWER.) However, depth of penetration does approach tubewall thickness. Although greater penetration is certainly desirable, previous experience shows this joint design will give consistently satisfactory welds between difficult-to-weld materials without adding filler metal.

Section II and IIIA samples are taken from assemblies using ⅞ in.-thick tube sheets. Remaining samples are from 1½ in.-thick tube sheets. Weld cross sections in similar combinations for every tube-sheet thickness are not shown. Heat application is sharply localized with high-speed automatic welding. So differences in tube-sheet metal thickness above one-quarter inch can be discounted as a factor in weld quality and penetration.

Chemistry, electrochemistry. When any dissimilar metal combinations are welded, it's a good idea to get information about chemistry of the resultant alloy to find out whether or not any important alloying elements are lost by volatilization or

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• • • says Mr. Armour Boese, Superintendent
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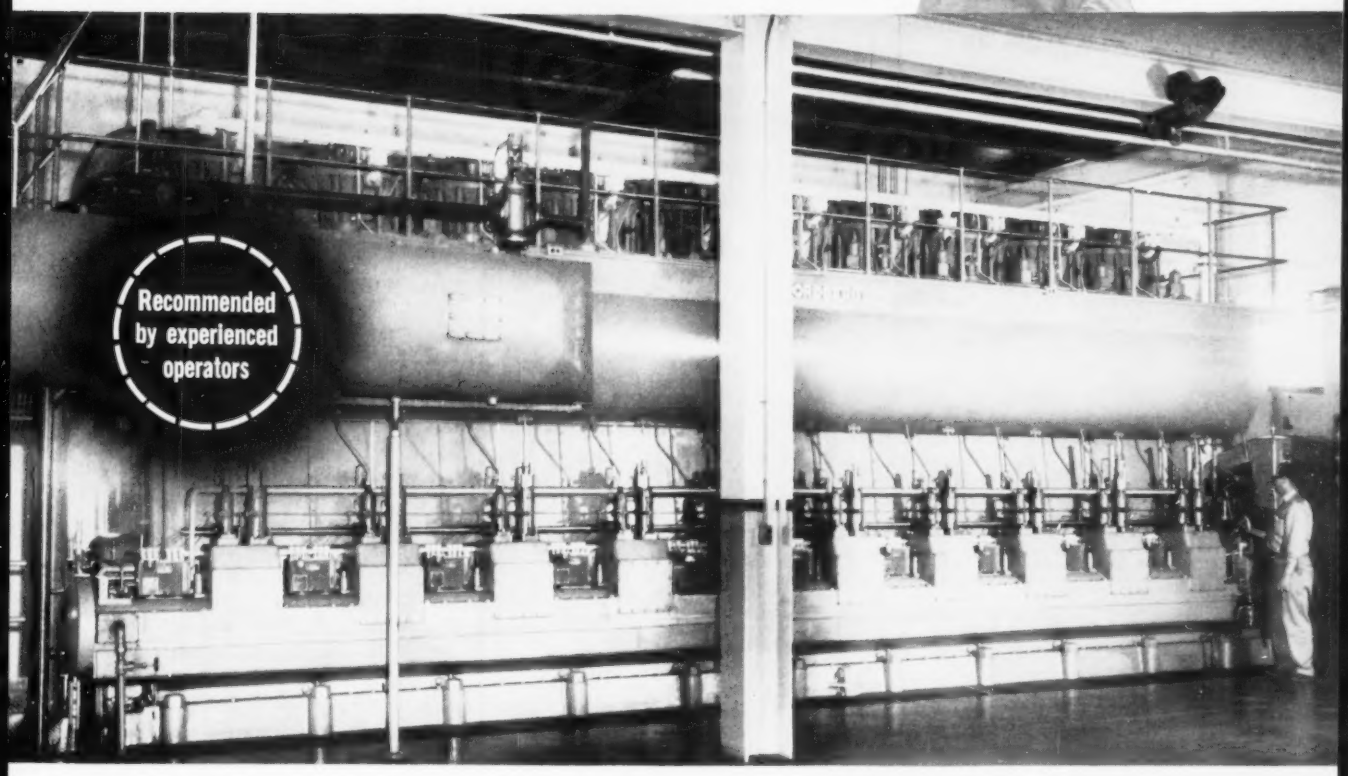

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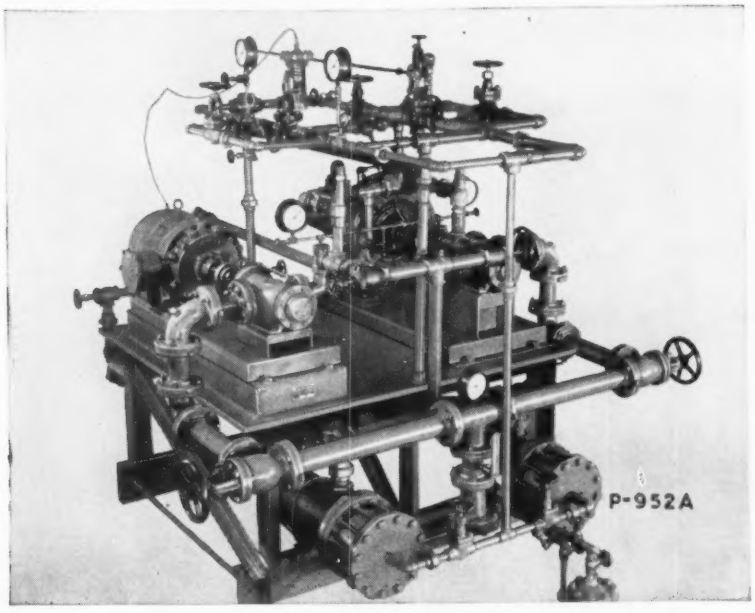

P-952A Steam Turbine and Electric Motor drive gives flexibility in this compact Model P-ES2H size No. 25 unit.

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NATIONAL AIROIL Fuel Oil Pumping and Heating Units are specially designed to prepare, for combustion, all grades of fuel oil including No. 6 or Bunker "C" Oil and residuums. They will draw fuel oil from above ground or underground tanks, preheat it to proper constant temperature and deliver it to Oil Burners at an even pressure, best suited for the burners. Our Fuel Oil Pumping and Heating Units are the result of years of experience. They come completely equipped ready for steam, exhaust, condensate, oil suction, oil return, and electrical connections. All valves, regulators, etc., are readily accessible. The piping arrangement is easily understood. These compact, space-saving units are available in a range of sizes and models in both Medium and High Pressure types. For complete details, write for our Bulletin 40 — very interesting and informative.

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Continued from page 214

oxidation. Minor alloying elements of aluminum, arsenic, silicon and tin play important roles in strength and corrosion resistance for the specific materials used.

An assay analysis is made for these alloying elements in each weld sample, representing all four material combinations. Each sample includes metal taken from six welds on each test assembly made with the material combinations in Section III. Weld metal is removed to a depth of 0.030 in. from initial contact by cutting with an 82-degree countersink.

This way we remove a relatively large percentage of weld metal with a high degree of assurance that unmelted base metal isn't included.

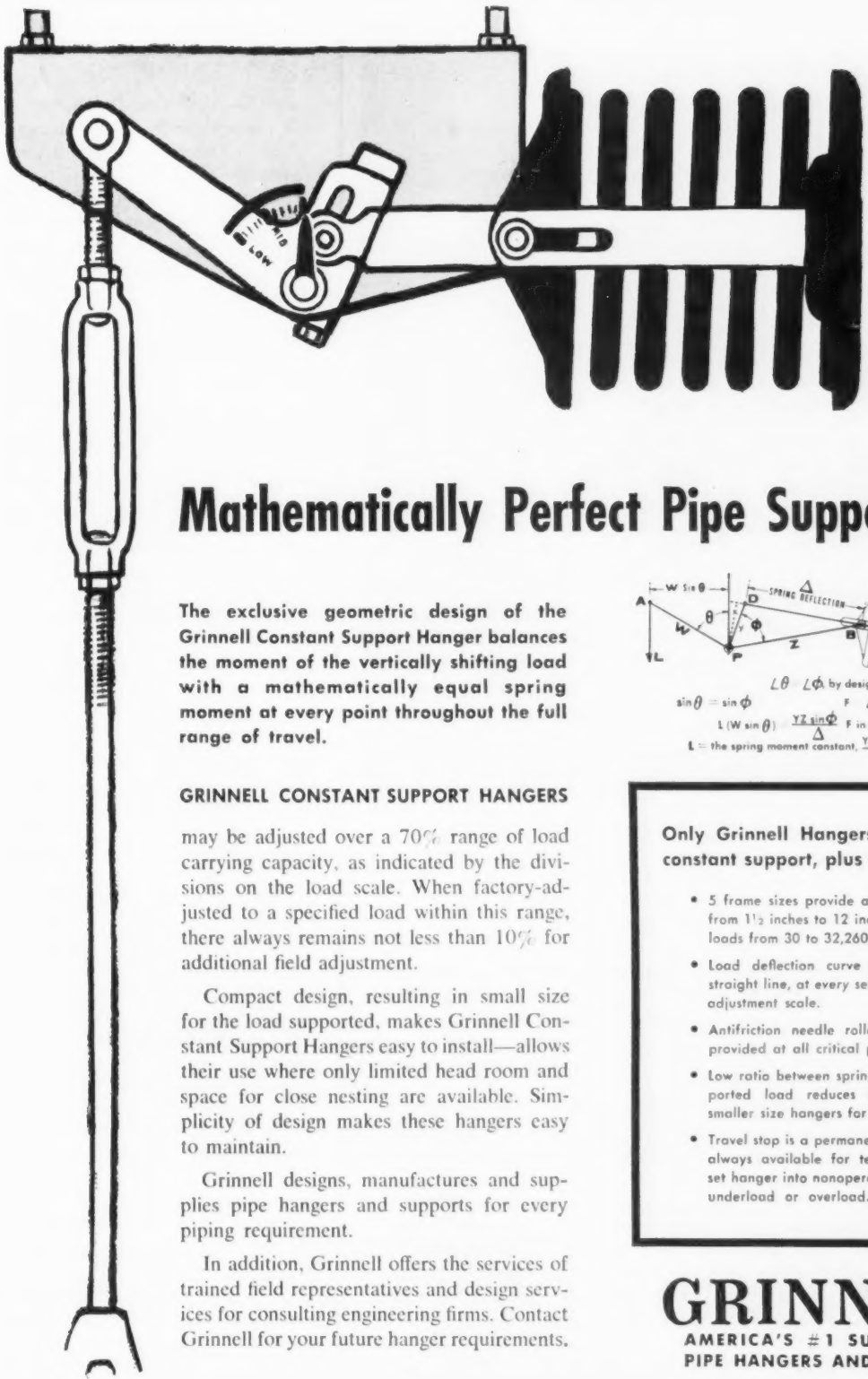
Table, page 110, gives average analysis of minor alloying elements in the weld admixture along with specified composition limits on aluminum, arsenic, silicon and tin originally present in the base metals.

Analysis of weld metal from the aluminum-brass tube—copper-silicon tube-sheet combination (Sections IIIA and C) shows 1.38% silicon, 0.94% aluminum, and 0.02% arsenic. Let's assume the copper-silicon tube sheet contains a nominal 3% silicon. Since silicon isn't lost during welding this amount indicates the weld metal has about 46% tube-sheet alloy. With this dilution ratio, 0.94% aluminum and 0.02% arsenic in the weld metal proves that hardly any of these elements are lost during welding.

Sample taken from the weld for the admiralty tube-copper-silicon tube sheet combination (Section IIIB and D) has 0.88% silicon giving a 30% dilution of tube-sheet material in the weld. In this case 70% dilution of tube alloy in the weld is consistent with the 0.03% arsenic content.

Welds from the aluminum-brass tube—naval-brass tube sheet combination (Section IIIE and G) show 0.33% tin. Since tin is present in the naval-brass tube sheet, at or near a nominal 0.75%, tube-sheet dilution in the weld metal is about 47%. Again this is compatible with weld metal arsenic of 0.3% and aluminum of 0.94%.

Weld sample from the admiralty tube—naval-brass tube sheet combination (Section IIIF and H) has 0.36% tin giving about 48% tube-



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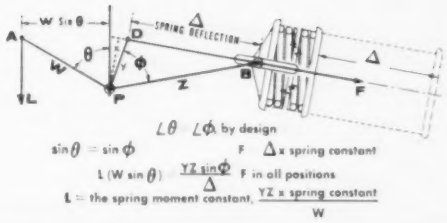

$\angle\theta = \angle\phi$ by design

$\sin\theta = \sin\phi$ $\quad F = \Delta \times$ spring constant

$L\,(W \sin\theta) = \frac{YZ \sin\Phi}{\Delta}$ $\quad F$ in all positions

L = the spring moment constant, $\frac{YZ \times \text{spring constant}}{W}$

GRINNELL CONSTANT SUPPORT HANGERS

may be adjusted over a 70% range of load carrying capacity, as indicated by the divisions on the load scale. When factory-adjusted to a specified load within this range, there always remains not less than 10% for additional field adjustment.

Compact design, resulting in small size for the load supported, makes Grinnell Constant Support Hangers easy to install—allows their use where only limited head room and space for close nesting are available. Simplicity of design makes these hangers easy to maintain.

Grinnell designs, manufactures and supplies pipe hangers and supports for every piping requirement.

In addition, Grinnell offers the services of trained field representatives and design services for consulting engineering firms. Contact Grinnell for your future hanger requirements.

Only Grinnell Hangers provide true constant support, plus these features:

- 5 frame sizes provide a range of travel from 1½ inches to 12 inches and support loads from 30 to 32,260 pounds.
- Load deflection curve is a horizontal straight line, at every setting on the load adjustment scale.
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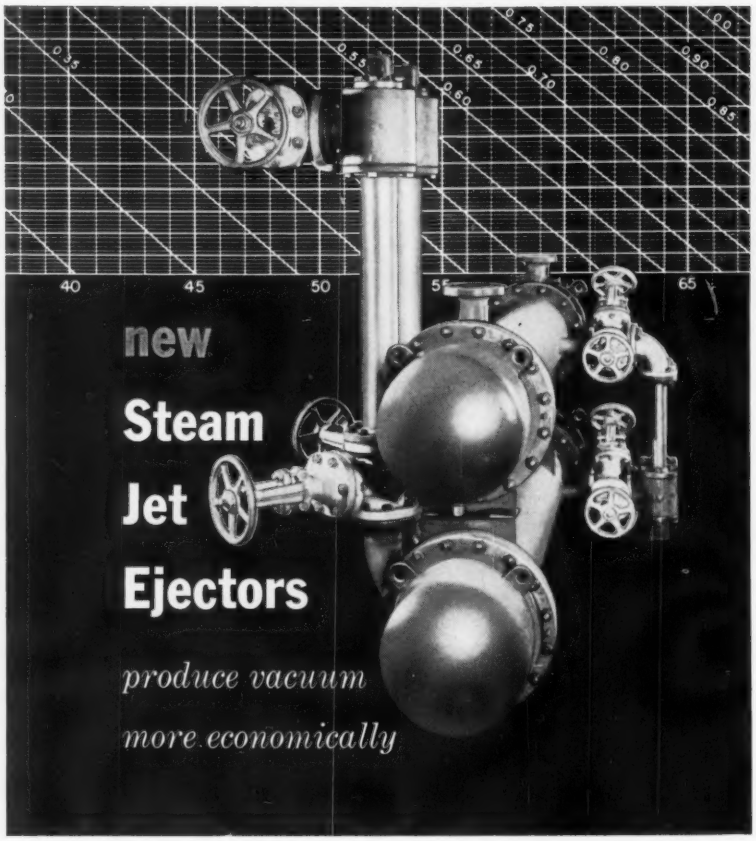

SWECO introduces a complete new line of steam jet ejectors, available in single and multiple stages and in a wide range of sizes and materials. Entirely new designs incorporate the most recent developments in the field—to meet the vacuum requirements of the power and process industries flexibly and efficiently.

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SWECO Steam Jet Ejectors are available from 1" to 8" and larger, and from 1 to 6 stages. For extra flexibility, any number of units may be used in parallel. Various combinations of inter-condensers and after-condensers can be provided for individual requirements.

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ENGINEERS AND CONSTRUCTORS...MANUFACTURERS

Welding

Continued from page 216

sheet alloy in the weld. Presence of 0.03% arsenic is then also consistent.

Note that in all cases where arsenic is added to high zinc alloys to reduce or prevent dezincification it's also present in the weld metal. And the quantity is high enough to combat this type of corrosion in the weld admixture.

Welding admixtures from the various tube and tube-sheet materials tested are actually new and unfamiliar alloys so tests were made to find their relative position in the electromotive series.

Table, page 111, gives the emf developed from various combinations of materials and their weld admixtures. All specimens are degreased with carbon tetrachloride. Samples are then treated with nitric acid to remove any surface film. Electrolyte for all cases is a 3% sodium-chloride solution.

In no case does the welding admixture in combination with either tube or tube-sheet materials produce a system where galvanic corrosion can progress at a high rate. Maximum difference in potential is well within what is normally considered safe.

Readings of potential were taken after 24 hours of sample immersion in a 3% NaCl electrolyte. Characteristics of the galvanic couples using a calomel half cell as a base are shown in Figure 3. It's interesting that in only one case out of four does potential across weld and the calomel cell fall between the potentials produced by calomel cell and the joint material. In the other three cases the weld admixture is more noble than either of the materials from which it is alloyed.

Conclusion. Cyclic-stress resistance of welded-only tube to tube-sheet joints is not satisfactory. But rolling in addition to welding does produce a joint with high endurance limits.

Welding admixtures of the various material combinations retain a good part of the minor alloying elements present in both tube and tube sheets. So their resistance to electrolytic corrosion is satisfactory compared to the corrosion-base materials from which they are formulated. All materials and admixtures fall within a narrow range in the electromotive series.

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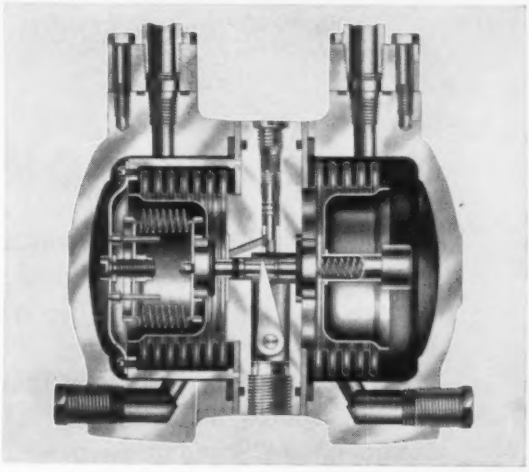

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Bookshelf

The Materials Handling Handbook. *Edited by Harold A Bolz, asso dean of the College of Engineering, Ohio State University. 1750 pp, illust, tables, charts, diagrams, $20.00. Ronald Press, N. Y.*

One of the most complete reference works available on its subject, this materials-handling reference volume was prepared by 84 editors under the sponsorship of AMHS and ASME.

Virtually all the progress made up to date in materials handling is covered. Methods of analyzing handling problems; principles, procedures and techniques for effective operation and control; systems design and installation; integration of materials-handling activities with the manufacturing processes; design, selection and classification of equipment are treated in 47 sections, each with a separate table of contents.

All types of conveyors, winches, cranes, power and hand trucks are discussed. One section shows how to set up and run a job-related training program.

This book is rapidly becoming recognized as the authoritative work in its field.

Pump Operation and Maintenance. *By Tyler G Hicks, instructor in mechanical engrg, Cooper Union School of Engrg. 275 pp, 6 x 9, illust. McGraw-Hill Book Co, 330 W 42nd St, New York 36, N. Y.*

Operation and maintenance of pumps for industrial, municipal, central station and other installations is discussed in a book aimed at supervising engineers, operators and maintenance personnel. Info is given for "cradle to grave" maintenance, from pump's arrival at the plant to the end of its service life.

Step-by-step instructions cover installation, starting up, routine operation, periodic maintenance, major overhaul. The approach is practical.

Up-to-date treatment includes discussion of barrel-type centrifugal pumps, pump-shaft metallizing, process-type centrifugal pumps, metering and proportioning pumps.

Thermodynamics. *By R L Swiegert, dean, graduate division, and M J Goglia, professor of mechanical*

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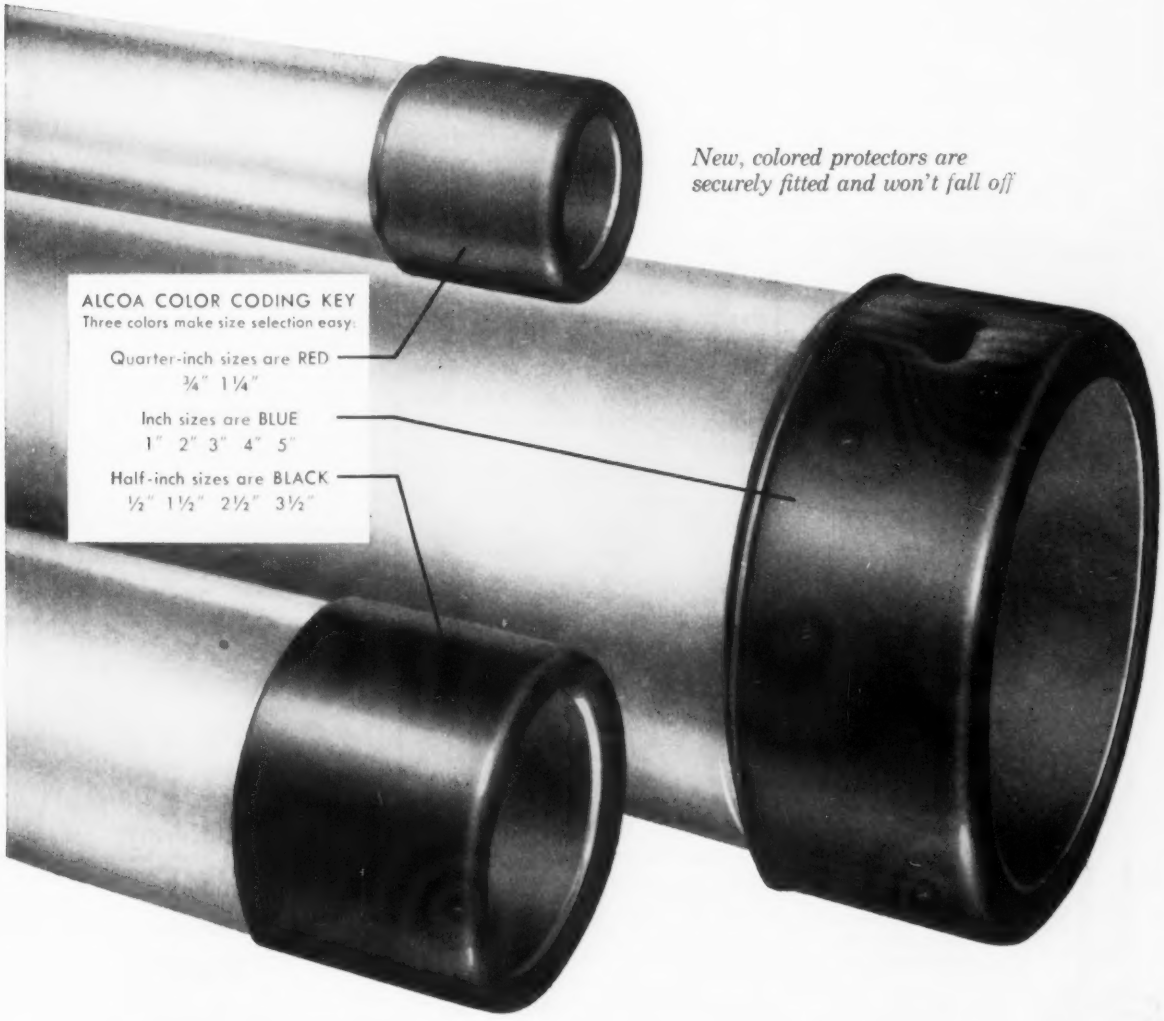
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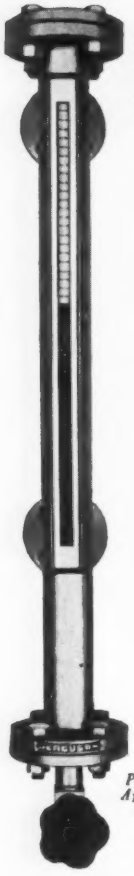

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Bookshelf

Begins on page 220

engineering, Georgia Institute of Technology. 6¼ x 9¼, 355 pp, illust. $6.50. The Ronald Press Co, 15 E 26th St, New York 10, N. Y.

The first three chapters explain the first and second laws of thermodynamics. Next is a review of the pure substance and perfect gas from the property standpoint. From here, the book goes on to discuss the basic processes and then launches into the thermodynamics of fluid flow.

Chapter 7 covers methods of listing thermodynamic data of pure and actual substances as in the gas and steam tables. Next comes a discussion of gas mixtures and vapor-gas mixtures. Chemical relations with thermodynamics are introduced from the standpoint of heats of reaction, combustion temperature, dissociation, and equilibrium constants. The book closes with a chapter on the applications in the form of power and refrigeration cycles, turbines, compressors and flow measurement.

Management for Engineers. *By Roger C Heimer, asso prof of mechanical engineering, Villanova University. 453 pp. $6.75. McGraw-Hill Book Co, Inc. 330 W 42nd St, New York 36, N. Y.*

Designed for the young engineer who hopes to become involved in his firm's decision-making processes, this book covers day-by-day workings of a business, as an economic institution and as a coordinate organization made up of individuals.

In discussing the mythical Z A Zalk Equipment Co, the author analyzes income contributions of the engineer and costs that *he* can control. The book takes a practical look at the impact of costs, standards, materials, methods, taxes, power, labor and ethics; treats basic record keeping; even delves into the field of depreciation accounting.

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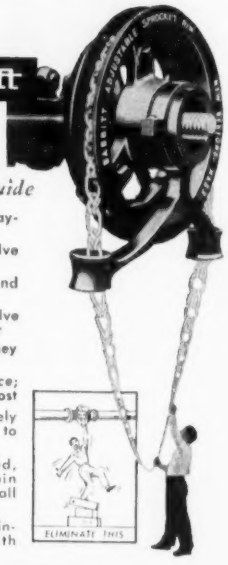

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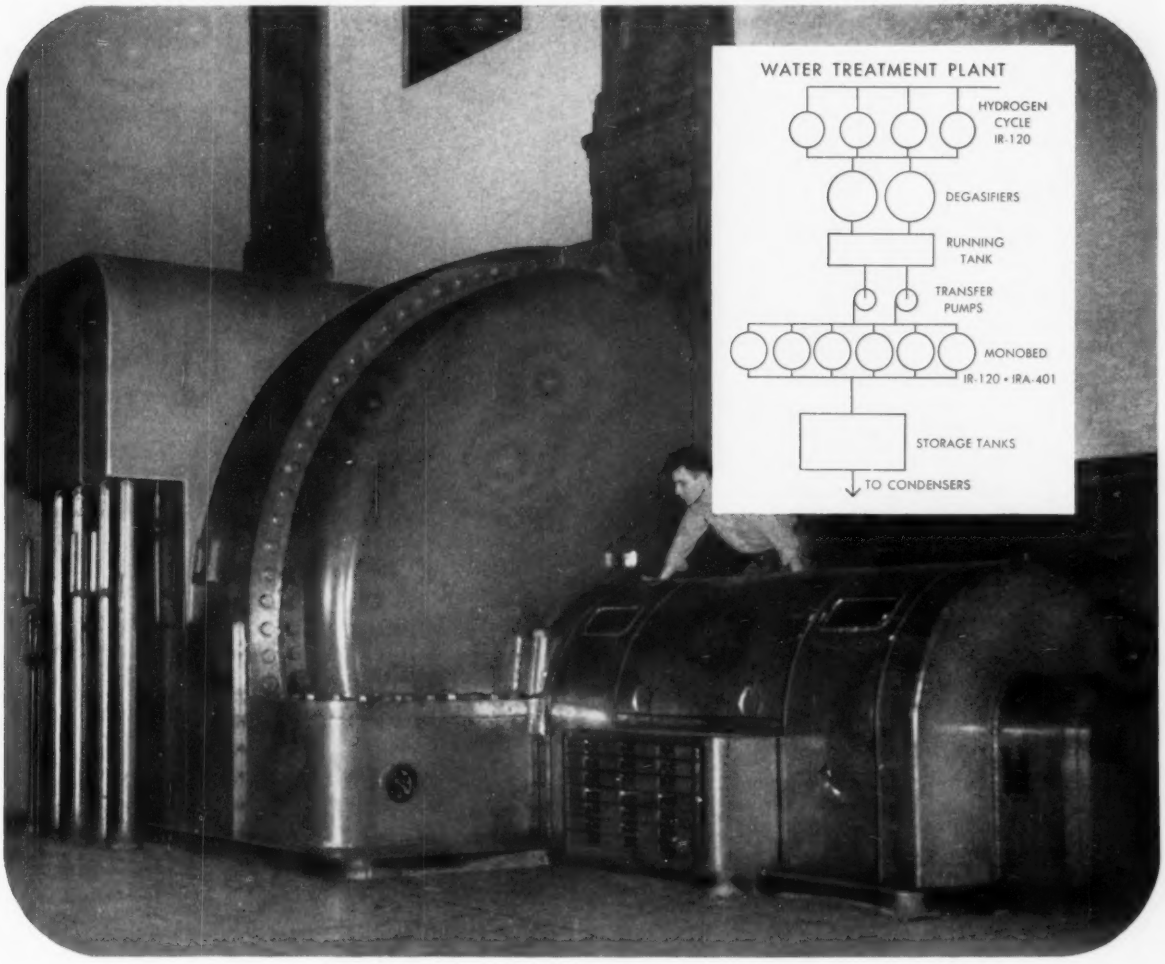

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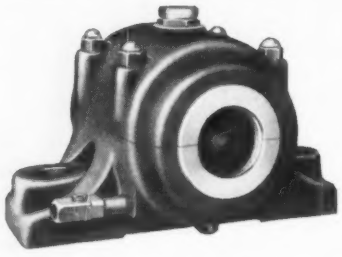

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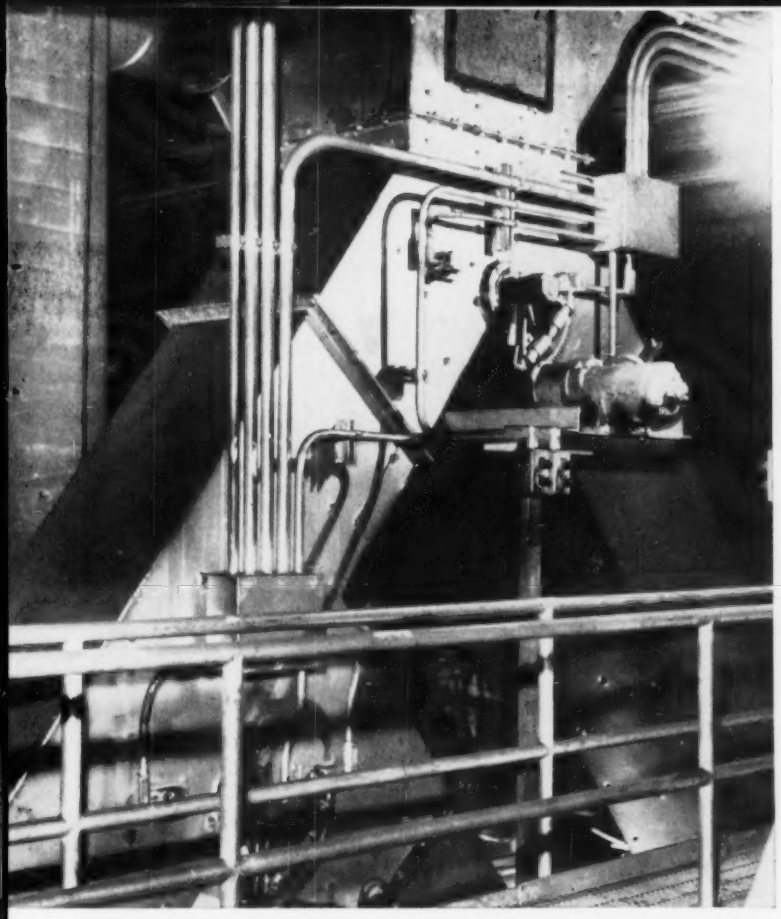

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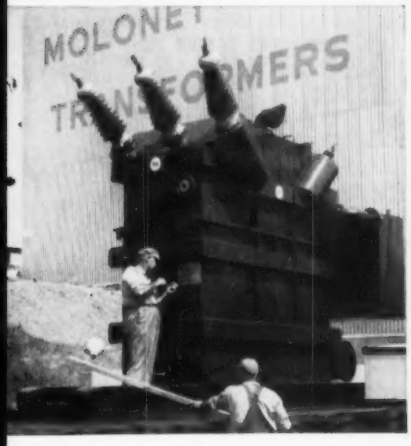
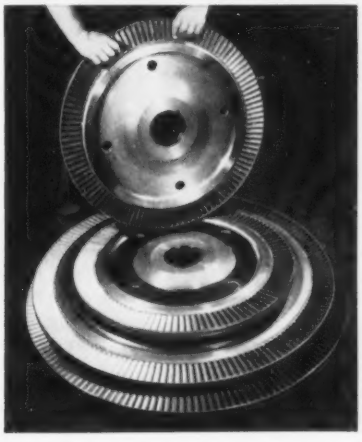


Over a ton of weight saved on this lighter-weight portable transformer. Shell thickness was reduced from $\frac{3}{8}$ to $\frac{1}{4}$ inch by designing to USS "T-1" Steel's greater strength.



60 per cent savings in material costs were realized by making these small turbine rotor discs from USS "T-1" Steel which has a yield strength of 90,000 psi minimum.

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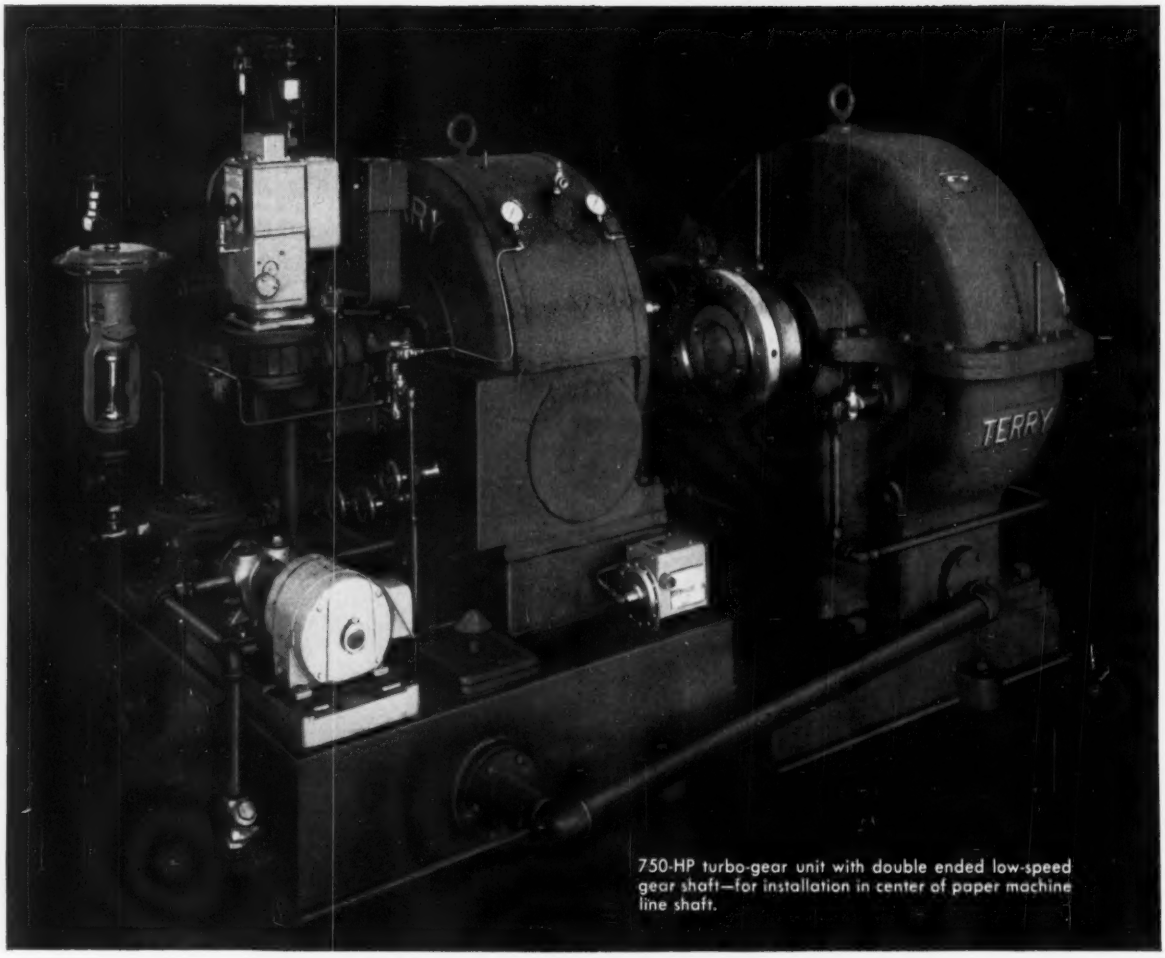
United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Supply – Steel Service Centers
United States Steel Export Company

United States Steel



750-HP turbo-gear unit with double ended low-speed gear shaft—for installation in center of paper machine line shaft.

LOW-SPEED TURBINE DRIVES

tailored to meet your requirements

For more than half a century, Terry has been one of the principal suppliers of turbo-gear units for driving slow-speed fans, generators, paper machines, large pumps and the like. Each unit is designed to meet the job requirements. The paper-machine drive illustrated is a good example of this *individualized engineering*.

In service at a large southeastern paper mill, the unit delivers 750 HP at 3350/500 RPM, with steam conditions of 450 lbs., 660°F and 50 lbs. back pressure. Equipped with a variable-speed governor, operated by remote control, the speed of the unit may be varied through a 10:1 range. Other features include forced-feed lubrication to turbine and gear bearings, and automatic shutdown and alarm in case of low oil pressure.

Whatever *your* requirements for low-speed turbine drives, a Terry engineer will be pleased to discuss them with you. Bulletin S-140 covers the full line of Terry turbines; Terry gears are described in bulletin S-130.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

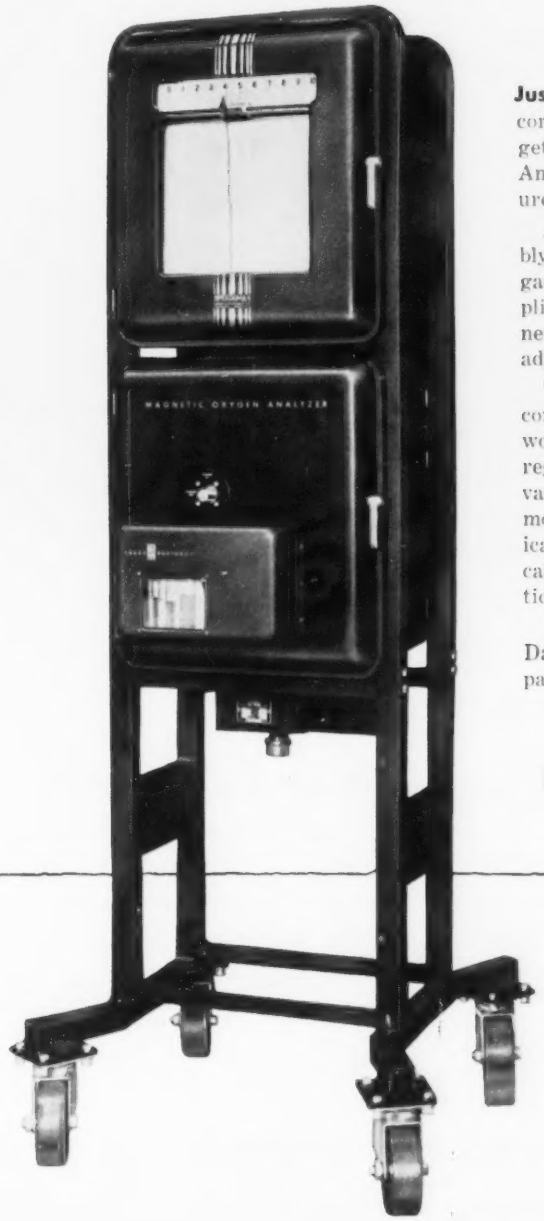
TERRY

TT-1212

GET O_2 DATA...

with new flue gas analyzer

ANYWHERE...ANY TIME...



Just roll this Magnetic O_2 Analyzer Recorder up to any sample pick-off point and get continuously recorded excess air data. And it's accurate data, for complete measurement is by direct magnetic action.

Already, operators are using the assembly for many purposes . . . checking flue gas stratification, verifying regular sampling points, exploring the suitability of new sampling points, checking for burner adjustment.

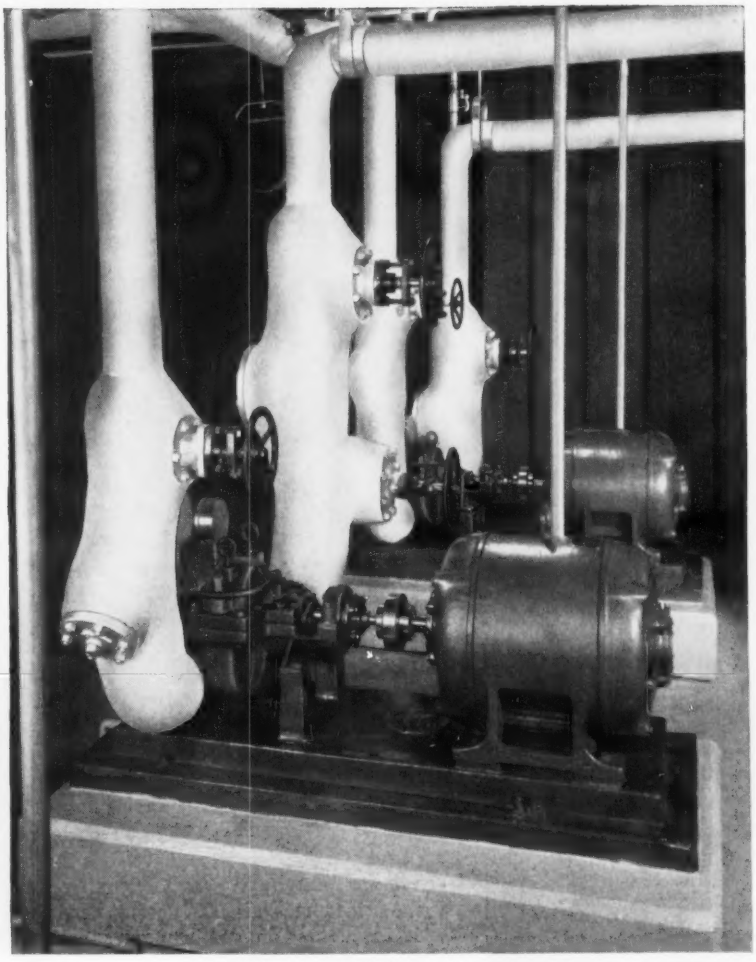
This rugged assembly is designed for continuous day-after-day operation . . . works from any 115-volt, 60 cycle non-regulated power source . . . has its own vacuum pump and sample cleaning filters mounted on the rear . . . doesn't need chemical reactions or auxiliary gas supplies for calibration and operation . . . requires practically no set-up time.

For more details write for Preliminary Data Sheet 463-61. Leeds & Northrup Company, 4910 Stenton Ave., Phila. 44, Pa.

LEEDS Instruments **NORTHRUP** Automatic Controls • Furnaces

PERFORMANCE

Range	0 to 5% O_2, 0 to 10% O_2, or higher in flue gas as specified
Accuracy	0.15% O_2
Sensitivity	Better than ±0.05% O_2
Stability	Better than ±0.15% O_2
Response	Initial response at Analyzer, 4 sec.; to 90% of full scale at Analyzer, 30 sec. Typical sampling lag, 1 sec. per 6 ft. of ½" plastic tubing



"Buffalo" Class "RR" Two-Stage Pumps

THEY PUMP MORE WATER AT LOWER COST

TESTIMONIALS from satisfied users prove the outstanding performance record of "Buffalo" Class "RR" Single Suction Multi-stage Pumps. These sturdy pumps are specially designed for high pressure and temperature clear water conditions.

The constant hydraulic balance of the "RR" design is the key to the high efficiencies these pumps deliver on the job. Rugged construction, generous bearings, extra-deep stuffing boxes — all add up to peak performance and long-lived dependability.

"Buffalo" Class "RR" Pumps are available in two and four-stage models, and in a variety of sizes to suit your needs. You will find them a best buy for any clear water service — hot or cold, at pressures up to 1500 ft. heads and at capacities from 20 gpm to 900 gpm.

Your nearby "Buffalo" Engineering Representative will be glad to show you the advantages of "Buffalo" Class "RR" Pumps — or write for Bulletin 980-E.

Every "Buffalo" product brings you the famous "Q" Factor — the built-in QUALITY which provides trouble-free satisfaction and long life.

BUFFALO PUMPS

DIVISION OF BUFFALO FORGE CO.

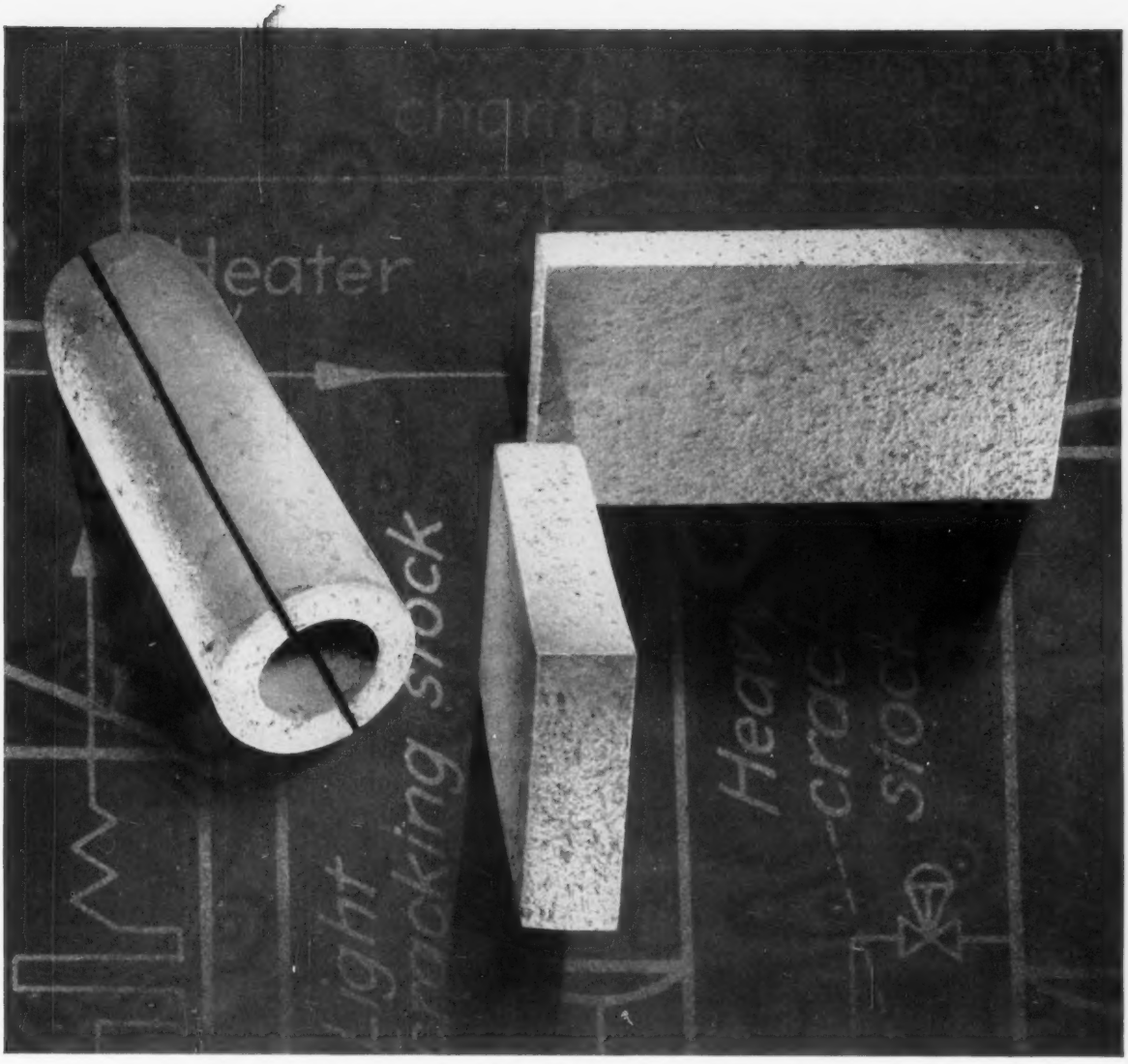
488 Broadway • Buffalo, N. Y.

Canada Pumps, Ltd., Kitchener, Ont.

Sales Representatives in all Principal Cities

"Buffalo" PUMPS

A BETTER CENTRIFUGAL PUMP FOR EVERY LIQUID



In petroleum refining, as in other process industries, "K&M" Insulations last the life of the equipment.

"K & M" High-Pressure Insulations permit more precise process control!

Permanent and trouble-free, "K&M" High-Pressure Insulations provide peak heating efficiency, lower fuel costs, and tighter heat control year after year. Maintain their insulating efficiency in spite of temperature changes, and other normal operating conditions.

Write to us today for a free brochure which shows how you can cut heating costs.

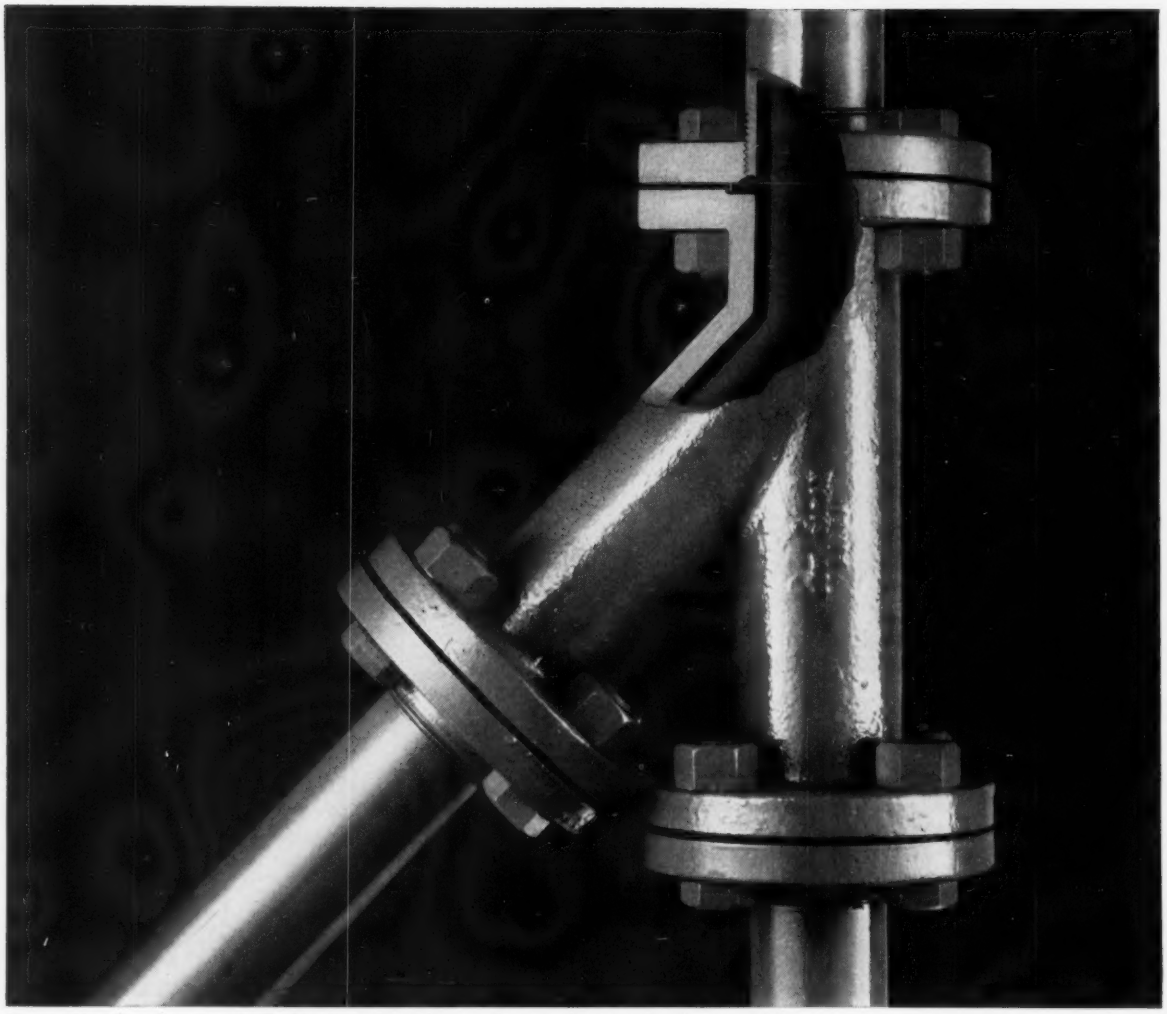
For temperatures up to 1900°F., use "K&M" Hy-Temp Combination—diatomaceous silica overlaid with "K&M" "Featherweight" 85% Magnesia. Staggered joints prevent heat loss through expansion-caused openings.

For temperatures up to 1350°F., use "K&M" Kaytherm—hydrous calcium silicate bonded with asbestos fibers. Important for power and petroleum applications.

For temperatures up to 600°F., use "K&M" "Featherweight" 85% Magnesia—a basic carbonate of magnesia mixed with asbestos fibers.

K·M
BEST IN ASBESTOS

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA



Cutaway view shows how corrosive liquids are prevented from touching metal in Saran lined pipe and fitting.

Here's why power engineers specify Saran lined pipe

It's rigid steel pipe lined with Saran . . . will not react with acid or chemically pure water

Power engineers are using more and more Saran lined pipe and Saraloy® 898 tank lining in water de-mineralizing systems. Tough, corrosion-resistant saran is an inert material that won't react with chemically pure water. With a complete system lined with saran and Saraloy, there is no danger of water contamination.

Pipe, valves, pumps and fittings lined with the new gray saran have many additional advantages. Its coefficient of thermal expansion more closely approaches that of its steel shell, providing a broader operating temperature range. It can be installed in systems operating from full vacuum to 300 psi and temperatures from −20°F. up to 200°F. Add to this the immediate availability from stock of Saran lined pipe, valves, pumps, fittings and Saraloy 898 tank lining and you have an ideal, reaction-free piping system.

Get all the details on why you should consider a complete system lined with saran and Saraloy. Write today. THE DOW CHEMICAL COMPANY, Midland, Michigan.

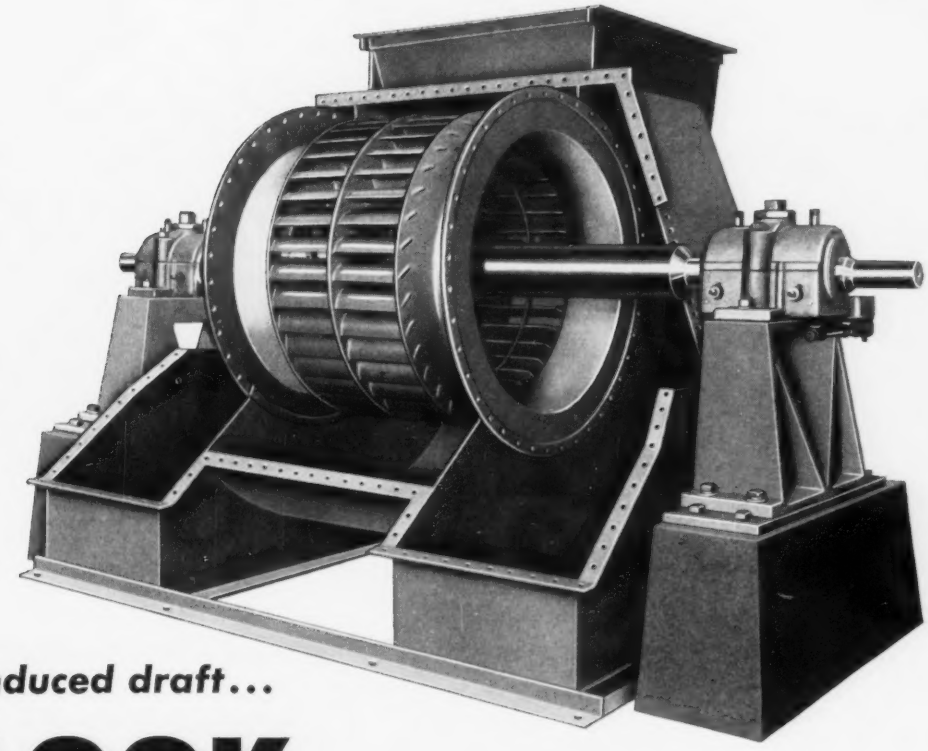
SARAN LINED PIPE COMPANY
DEPT. 2005H-1
2415 BURDETTE AVENUE
FERNDALE 20, MICHIGAN

Please send me information on:
☐ Saran lined pipe, fittings and valves. ☐ Saran lined centrifugal pumps. ☐ Saraloy 898 chemical-resistant sheeting.

Name_____ Title_____ Company_____

Address_____ City_____ State_____

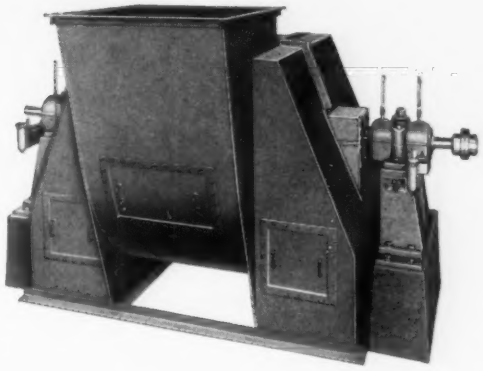
YOU CAN DEPEND ON DOW



For induced draft...

LOOK what Clarage's new Type DN Dynacurve Fan offers you

1. LOW cost.
2. LOW tip speed.
3. LOW moment of inertia (WR^2).
4. HIGH efficiency.
5. HIGH dynamic conversion.
6. HIGH standards of construction.



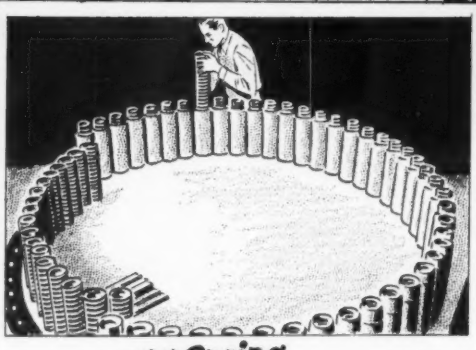
Write today for Catalog 905. Clarage Fan Co., Kalamazoo, Mich.

CLARAGE ...*dependable equipment for making air your servant*

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal

A "stitch-in-time" (Monel) once saved Miss Liberty

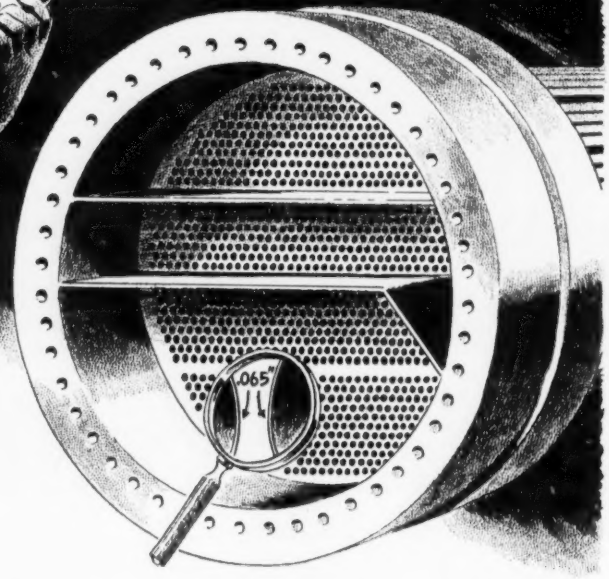
IN 1938 MISS LIBERTY WAS DANGEROUSLY CLOSE TO FALLING APART AT THE SEAMS. CORROSIVE ATTACK BY SALT AIR AND INDUSTRIAL FUMES HAD WEAKENED AND LOOSENED RIVETS HOLDING THE STATUE'S HUGE METAL PLATES TOGETHER. BUT SHE WAS SAVED BY 65,000 MONEL* NICKEL-COPPER ALLOY SELF-TAPPING SCREWS WHICH PULLED THE PLATES UP TIGHT. THESE STRONG, CORROSION-RESISTING "STITCHES" STILL LOOK GOOD TODAY—20 YEARS LATER.



Inconel "X" Spring starves "hungry" water...

Withstands corrosive bite of 13,000 tons per hour, at 600°F

13,000 TONS PER HOUR OF HIGH-PURITY WATER AT 500-600°F FLOW THROUGH THE CORE MOUNT SPRINGS OF A NUCLEAR POWER REACTOR. TO PREVENT STRESS-CORROSION CRACKING OR EMBRITTLEMENT, THE DESIGNERS CALLED FOR INCONEL* "X"* AGE-HARDENABLE NICKEL-CHROMIUM ALLOY. SPRINGS MADE OF THIS ALLOY RESIST CORROSION AND RELAXATION AT HIGH TEMPERATURES—UP TO 1100°F IN SOME CASES!



Thin-wall 4300psi heater tubes—5/8" O.D.

THESE ARE THE FACTS ON THE MONEL ALLOY U-TUBES IN FINAL STAGE FEEDWATER HEATERS, NOW AT A NEW OHIO POWER STATION. THEIR 85-FOOT LENGTH MAKES THEM THE LONGEST MONEL ALLOY TUBES EVER MADE. ALTHOUGH THESE TUBES ARE DESIGNED TO WITHSTAND A WATER PRESSURE OF 4300 PSI, THEY'RE ATTACHED TO THE TUBE SHEETS BY ROLLING ONLY! QUITE A TRIBUTE TO STRENGTH AND DUCTILITY OF MONEL ALLOY.

Need help on a metal problem?

THERE'S A GOOD CHANCE THAT INCO'S MECHANICAL ENGINEERING SECTION HAS ALREADY SOLVED A PROBLEM SIMILAR TO YOURS. WHY NOT CONTACT THEM RIGHT AWAY FOR ASSISTANCE? JUST LET US KNOW THE DETAILS.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street — New York 5, N. Y.

INCO

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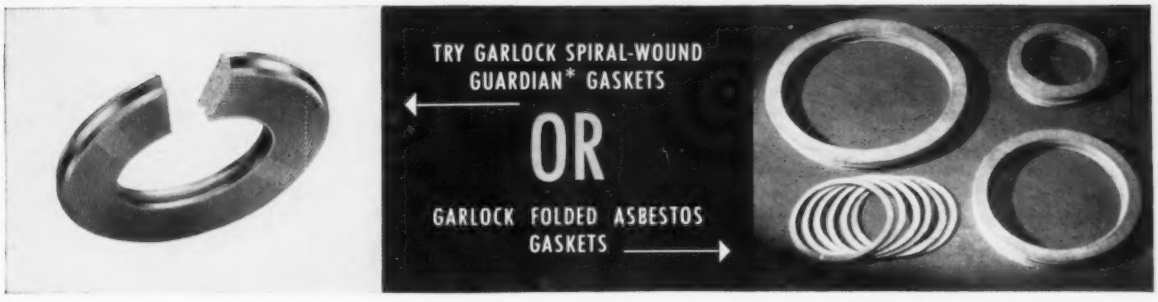
INCO NICKEL ALLOYS

Sealing against high temperatures?



Garlock Spiral-wound Guardian Gaskets provide safe, positive sealing at temperatures to 1050° F. and pressures to 2500 psi. . . . and under lighter bolt loads, too! They are recommended for sealing against oils, steam, gases, liquids and most chemicals. In no other type gasket can you vary the compressibility to meet different requirements. They are constructed of spiral wound strips of V-shaped metal alternated with layers of asbestos paper or Teflon. Type metal and filler depend upon application. Ask for folder AD-104.

Garlock Folded Asbestos Gaskets are recommended for use against steam or gases to 600° F. where surfaces are irregular or pitted. They are most commonly used on boiler manholes and handholes, or on flanged joints of column stills or other equipment requiring a soft gasketing. Made of wire-inserted asbestos cloth, specially treated to withstand high temperatures, the gaskets are folded, formed and pressed to produce any desired shape.

Guardian Gaskets and Folded Asbestos Gaskets are just two more examples of the famous "Garlock 2,000" . . . two thousand styles of packings, gaskets, and seals for every need. The *only* complete line. You can ask your local Garlock representative for his unbiased recommendations. Or, write for Gasket Folder AD-162.

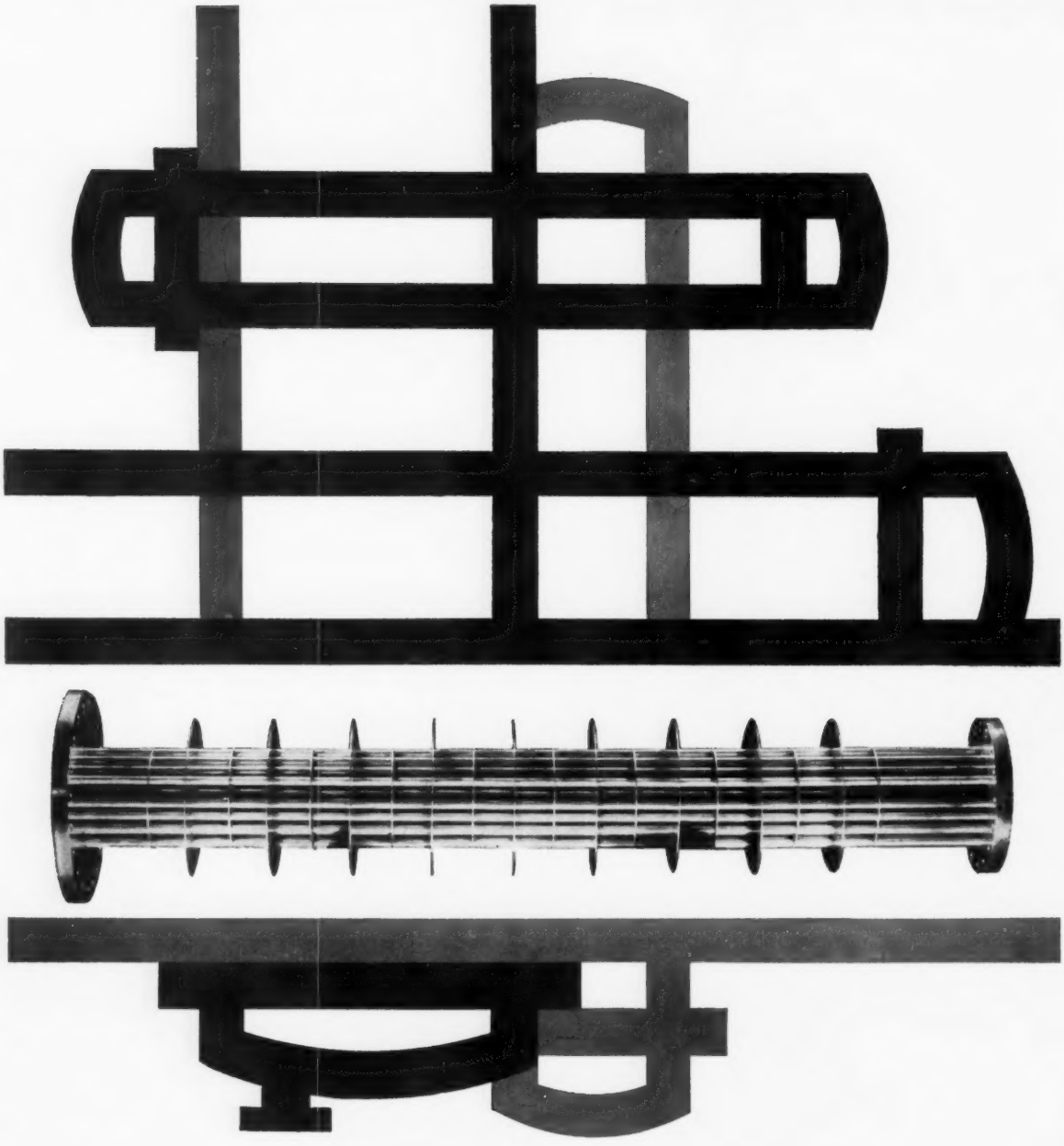
*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

For prompt service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products



win the fight against corrosion—with Alcoa Aluminum

Here's a $100-million example. The refining industry's requirements for heat exchanger tubes are 40 ft per barrel of capacity. Some 30 ft of this requirement involves exchanger applications in which Alcoa has proved aluminum is ideal. By using aluminum tubes in all those applications, the refining industry would have saved approximately $37 million in original capital investment. Capitalized at the refining industry's normal rate of return, that saving would be worth about $100 million over a 10-year operating period.

Don't shovel good money after bad by reinstalling unsuitable material. Over 30 years' experience in the process industries has given Alcoa engineers full knowledge of the aluminum alloys and installation methods by which corrosion can be eliminated. Put their knowledge to work for you. Outline your corrosion problems in a letter to ALUMINUM COMPANY OF AMERICA, 888-F Alcoa Building, Pittsburgh 19, Pa.

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

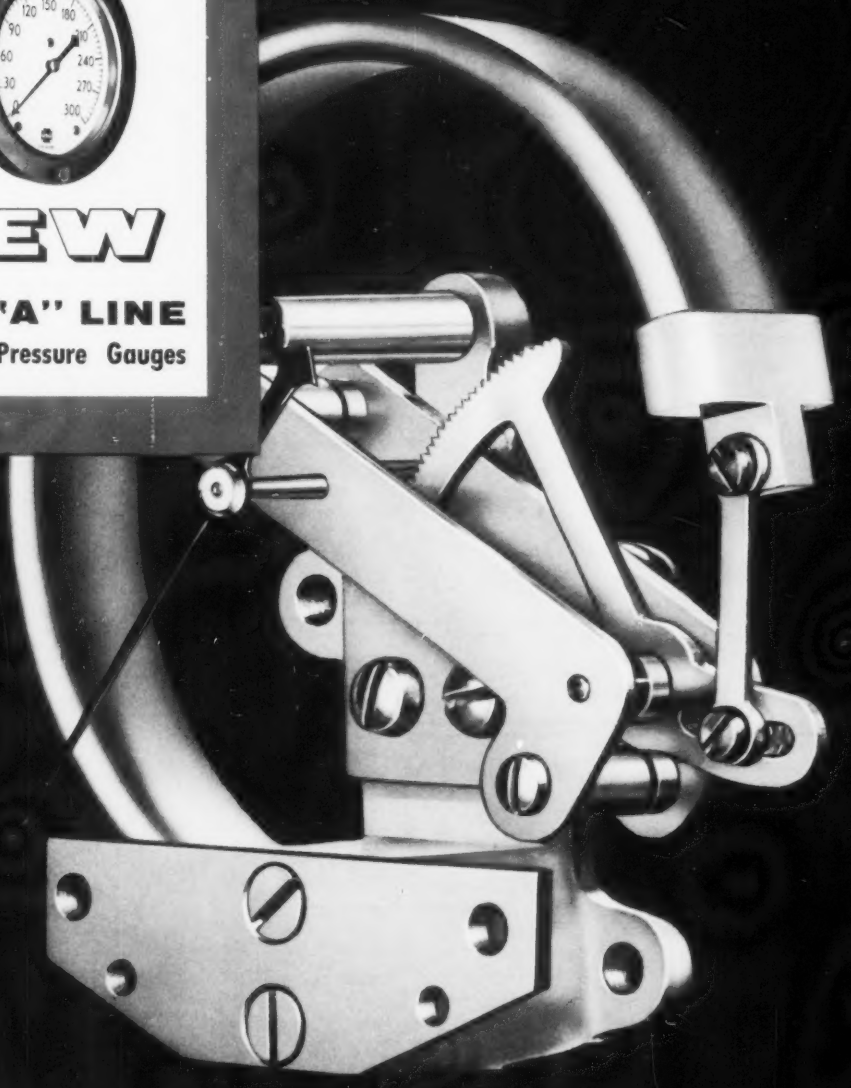
ALCOA CHEMICALS

Specify Alcoa Aluminum for
corrosion-free Process Equipment
Pipe & Tube
Tanks, Containers, Trucks & Cars
Plant Structures

NEW

USG "A" LINE

Industrial Pressure Gauges



NEVER BEFORE A GAUGE VALUE LIKE THIS!

MEETS A.S.A. GRADE A STANDARDS . . . Guaranteed accurate within 1% of scale for the middle (working) half of scale, and 1½% for remainder.

HAS PREMIUM GAUGE CONSTRUCTION . . . Wide choice of options in cases, movements, tubes, sizes, and ranges—including many features of USG's premium line.

PRICES ARE LOW! You'll have to see the new USG "A" Line gauges to believe all they offer . . . at up to 40% below premium prices.

(please turn page for more details)

Call your USG Distributor for a personal demonstration of these features.

UNITED STATES GAUGE

DIVISION OF AMERICAN MACHINE AND METALS, INC., SELLERSVILLE, PA.

USG®

if you are looking for

ACCURACY
QUALITY FEATURES
LONG LIFE
EASY MAINTENANCE
LOW COST
GOOD DELIVERIES

HAVE YOU SEEN THE NEW USG "A" LINE YET?

Call your USG Distributor for a personal demonstration of these features.

WHEN YOU SEE THESE GAUGES, YOU WON'T BELIEVE THE LOW PRICES!

FOR A HOST OF INDUSTRIAL APPLICATIONS

Be sure to check the new "A" Line models against your specifications for any of a broad range of industrial applications.

Save your costs of pressure measurements—principally where steam, water, and oil pressures must be indicated in:

power and steam plant utilities • air conditioning and refrigeration systems • hydraulic presses • metalworking plants

CHOOSE FROM THESE STANDARD A-LINE COMBINATIONS

CONSTRUCTION	GAUGE APPLICATION	GENERAL UTILITY								ALTITUDE								REFRIGERATION (EXCEPT AMMONIA)								AMMONIA						HYDRAULIC							
	FIGURE NUMBER	5001	5002	5003	5004	5005	5006	5007	5009	5021	5022	5023	5024	5025	5026	5027	5029	5041	5042	5043	5044	5045	5046	5047	5049	5061	5062	5063	5065	5067	5069	5091	5092	5093	5094	5095	5096	5097	5099
AVAILABLE SIZES	3½"	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
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	6"	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	8½"	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	12"	•	•	•	•		•																									•	•	•	•		•		
CASE	Aluminum, Back Flange	•	•							•	•							•	•							•	•					•	•						
	Aluminum, Front Flange			•								•								•								•						•					
	Brass, Back Flange				•								•								•								•						•				
	Cast Iron, Back Flange					•	•							•	•							•	•							•						•	•		
	Cast Iron, Front Flange							•								•								•							•							•	
	Phenolic, Turret								•								•								•						•								•
RING	Steel Peaked, (Slip)	a				•				•				•				•				•				•			•			a				•			
	Aluminum Peaked, (Threaded)		•								•								•								•						•					
	Steel, (Hinged)			b				•				•				•					•				•				•		•			b				•	
	Brass Peaked, (Threaded)				•		•						•		•							•		•											•		•		
	Steel, (Snap)								•								•								•						•								•
MOVEMENT	Brass	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•														
	*Stainless Steel and Nylon																															•	•	•	•	•	•	•	•
	**Stainless Steel																									•	•	•	•	•	•	•	•	•	•	•	•	•	•
BOURDON TUBE	Phosphor Bronze	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•														
	Stainless Steel, 316																									•	•	•	•	•	•								
	Stainless Steel, 403																															•	•	•	•	•	•	•	•
SOCKET	Brass	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•														
	Alloy Steel																									•	•	•	•	•	•	•	•	•	•	•	•	•	•
CONNECTION	Bottom	•	•		•	•	•		•	•	•		•	•	•		•	•	•		•	•	•		•	•	•		•		•	•		•	•		•	
	Low Back	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

*Except 3½" size. **On 5090 series only, a stainless steel movement is used for 3½" size.

(a) Steel peaked slip ring, except for 12" where cast aluminum slip ring is furnished.
(b) Steel hinged ring, except for 12" where cast brass slip ring is furnished.

Find Your Nearest Distributor In The 'Yellow Pages'

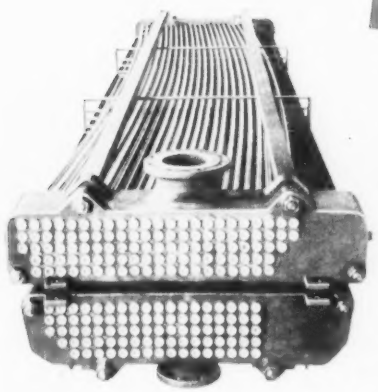
For NEW CATALOG 305 "Pressure Gauges for General Industry", call your nearest USG Distributor . . . or write to us direct.

UNITED STATES GAUGE

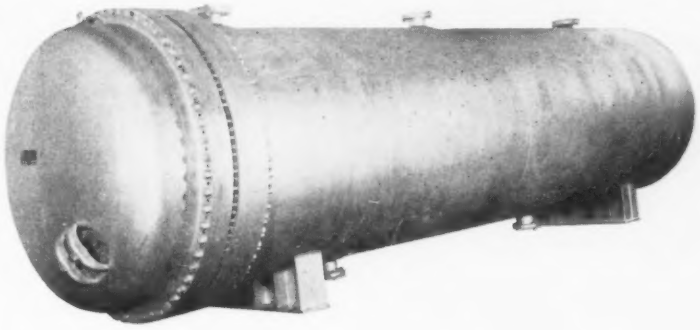
DIVISION OF AMERICAN MACHINE AND METALS, INC., SELLERSVILLE, PA.

USG

G-R designed for power plants



Photograph of G-R Bentube tube bundle showing the initial bow of the tubes. Temperature changes vary the magnitude of the bend and the resultant flexing sheds scale from the tubes.



G-R Scale-Shedding Evaporators

G-R Bentube Evaporators provide boiler feedwater guaranteed to highest purities, long service life and minimum maintenance.

Highest purity dry vapor results from the use of a patented centrifugal moisture separator, large vapor space for moisture disengagement and splash baffling.

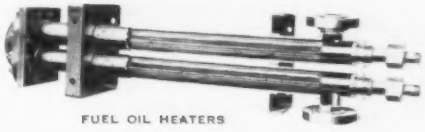
Long life and low maintenance are provided by a number of design features. G-R's exclusive Bentube design sheds scale through the controlled expansion of the tubes. This Bentube construction also offers easier tube cleaning and replacement since no U-bends are used.

Available in three designs for moderate, high and low capacities and pressures, G-R's 80-plus years of heat exchanger experience assure you of highest overall quality.

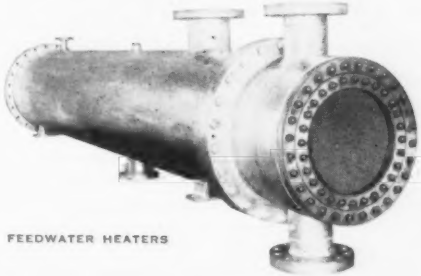
Send for Griscom-Russell Bulletin 501A

G-R Designs for Power Generation

GENERATOR COOLERS



FUEL OIL HEATERS



FEEDWATER HEATERS

- Evaporators • Air Preheaters • Fuel Oil Heaters
- Storage Tank Oil Heaters • Drain Coolers
- Feedwater Heaters • Transformer Oil Coolers
- Generator Coolers • Lubricating Oil Coolers

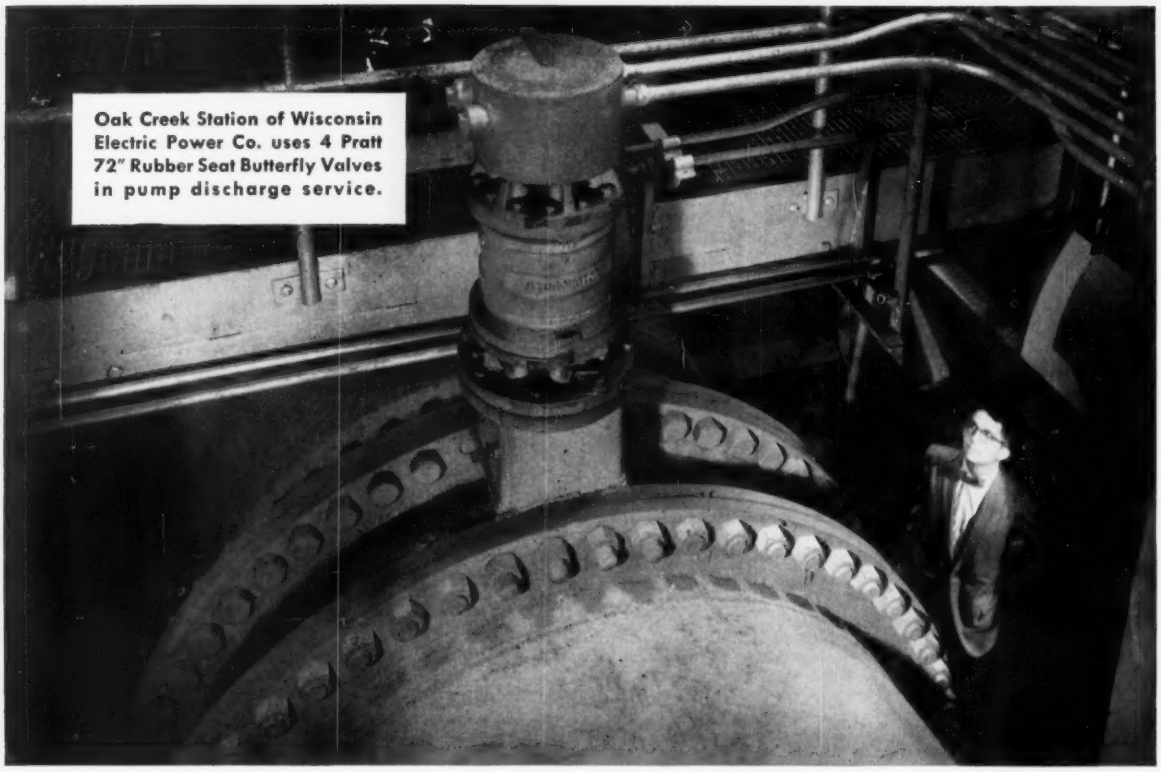
HEAT EXCHANGE EQUIPMENT FOR THE POWER INDUSTRY GR 367

Griscom-Russell

GENERAL PRECISION EQUIPMENT CORPORATION GPE

THE GRISCOM-RUSSELL COMPANY • MASSILLON, OHIO

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION



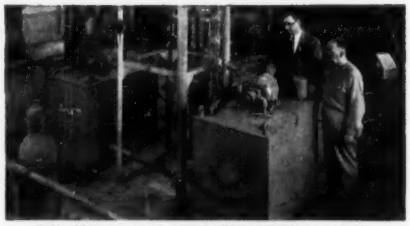
Oak Creek Station of Wisconsin Electric Power Co. uses 4 Pratt 72" Rubber Seat Butterfly Valves in pump discharge service.

MILWAUKEE...Pratt Butterfly Valves offer "two valves in one" for pump discharge

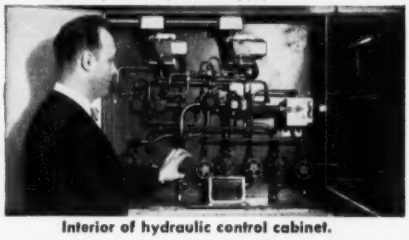
Pratt Rubber Seat Butterfly Valves in pump discharge service can be made to open and close in synchronization with pump operation, AND they close drop tight—combining, in a single valve, the functions normally achieved by separate shutoff and check valves. The simple combination of disc, shaft and efficient closure provides years of dependable performance without maintenance problems.

Pump discharge valves at Oak Creek Power Plant are hydraulically operated with oil motors. The electro-hydraulic system includes a bank of accumulators and complete auxiliary manual controls to permit operation under any emergency condition.

Pratt pioneered the use of rubber seat butterfly valves in power plants, and today offers the greatest aggregate experience on butterfly valving in the power field. For valve design—**with imagination**—see Henry Pratt.



Felix Kazmerchak, Ass't. Plant Engineer, and Ray F. Egebrecht, Pratt Representative, inspect hydraulic power supply.



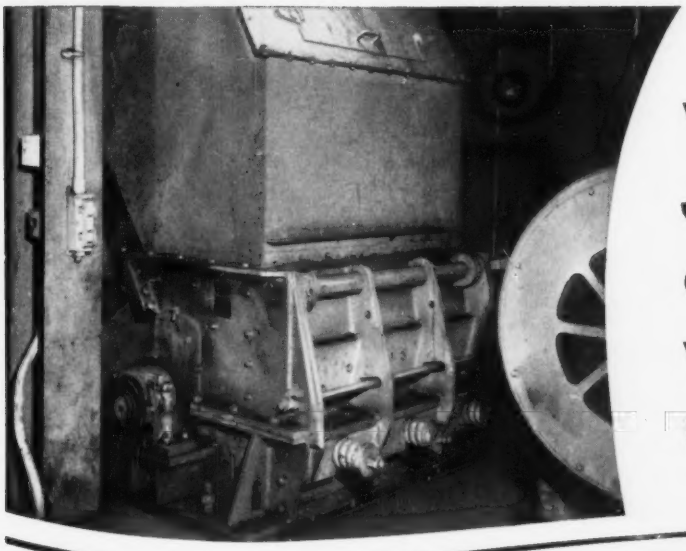
Interior of hydraulic control cabinet.

Have you sent for your copy?...of Pratt's 40 page **Manual of Rubber Seat Butterfly Valves.** Useful—contains latest pressure drop and flow data, conversion tables, butterfly valve theory and application. **CATALOG B-2K**

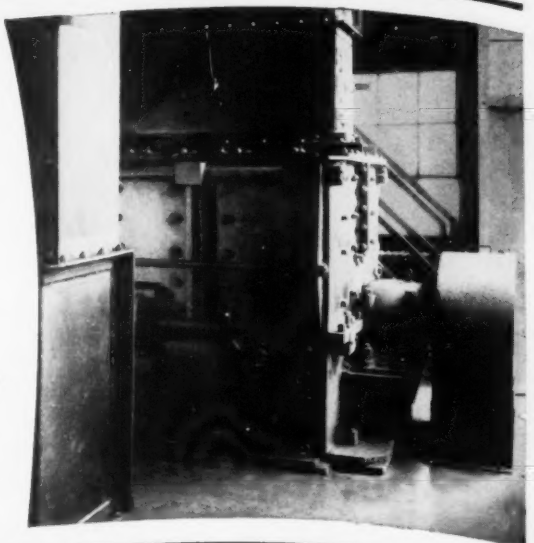
HENRY PRATT

RUBBER SEAT Butterfly Valves

Henry Pratt Company, 2222 S. Halsted St., Chicago 8, Ill. Representatives in principal cities



which of these **JEFFREY** coal crushers will meet your needs?



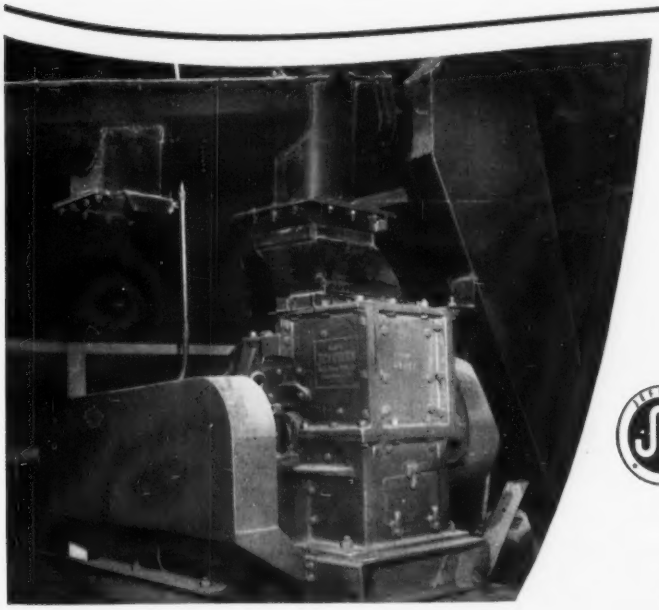
SINGLE AND DOUBLE roll crushers, FLEXTOOTH® and FLEXROLL® crushers, swing hammer pulverizers—Jeffrey makes all the popular types used in power plants, large or small.

Care in selecting the proper type of crusher means the difference between an efficient installation and one that bottlenecks coal moving through the plant.

Our engineers will gladly give you complete satisfaction on your problem, using their years of experience with every conceivable crushing case.

Jeffrey also offers the most complete test history file of any manufacturer of crushing equipment, plus a fully equipped laboratory where tests on coal in doubtful cases will be run at no expense or obligation to you.

For more information, write for Catalog 784-C. The Jeffrey Manufacturing Company, Columbus 16, Ohio.



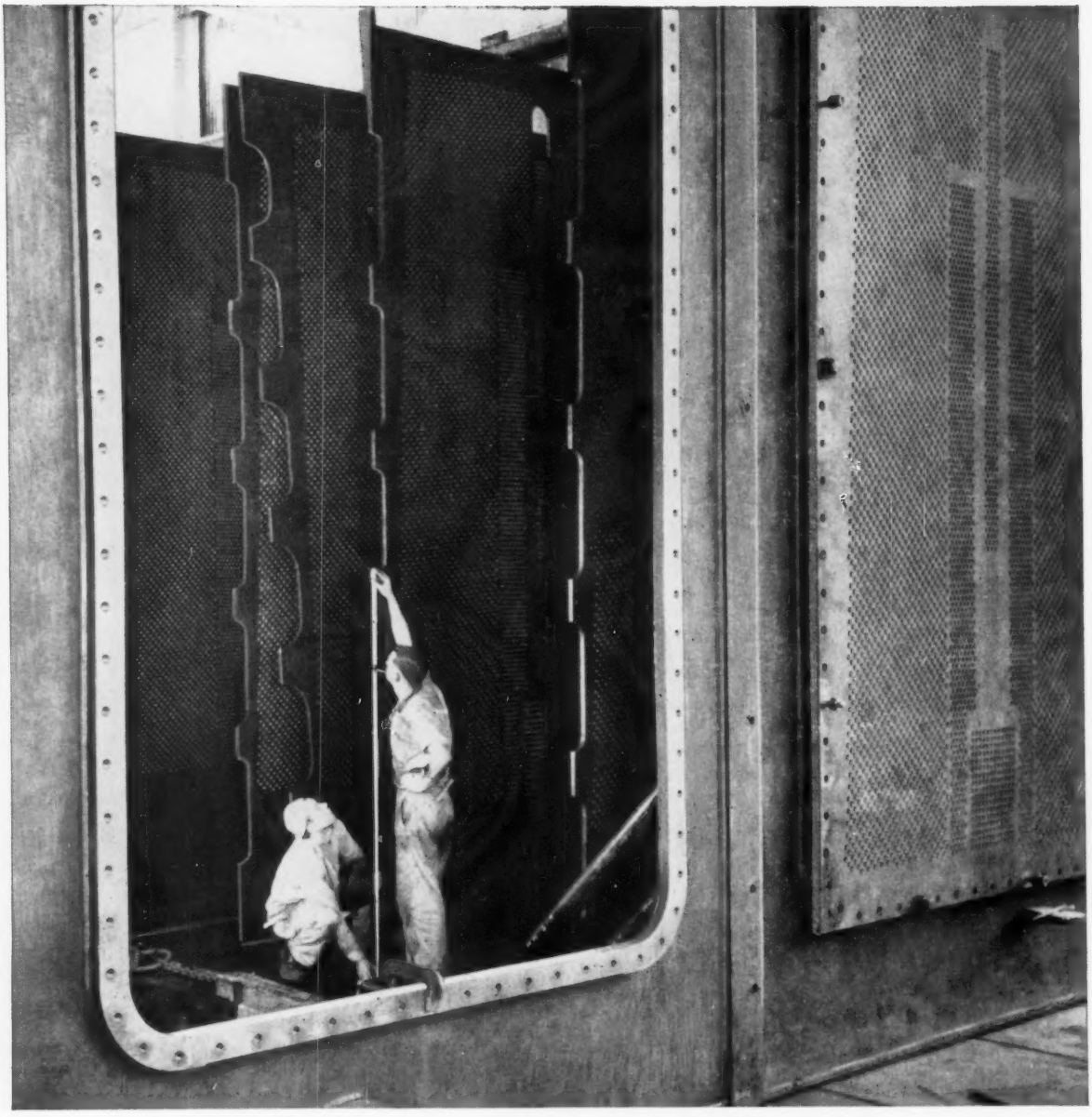
Top: *42" x 66" FLEXTOOTH for coal reduction to minus 1" or ¾".*

Center: *42" x 82" Type B Reversible Swing Hammer for crushing coal down to minus ⅛".*

Bottom: *20" x 12" Type A-2 Swing Hammer Pulverizer for medium and small capacity plants, also in sampling operations. Reduction down to minus ½" to 10 mesh.*

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT
TRANSMISSION MACHINERY • CONTRACT MANUFACTURING



Twin-shell, triple-lane, single-pass Condenser with 187,000 sq. ft. capacity. One of largest units ever built, it was recently installed at large eastern utility.

In tube layout, too... design makes the difference with C. H. Wheeler condensers

You see here one of the many reasons why C. H. Wheeler Dual Bank Surface Condensers operate so efficiently in scores of public utilities and industrial plants throughout the country.

Triple Lane Tube Layout, with three separate pathways for steam travel, allows the steam to penetrate to the peripheries of all tubes.*

Design like this, typical of C. H. Wheeler engineering, steps up condenser efficiency. Other engineering advancements—such as patented Reverse Flow, which permits flushing away leaves, twigs, algae and other foreign matter—reduce maintenance requirements. "Zero" condensate temperature depression, pure condensate and deaeration to 0.03 cc. of oxygen per liter (special design provides for deaeration to 0.01 cc. of oxygen per liter) . . . are additional features you get with C. H. Wheeler Condensers.

**Location of the air-vapor take-off reduces the resistance to steam passage. This minimizes the depth of steam penetration through the tube bank of all C. H. Wheeler Condensers.*

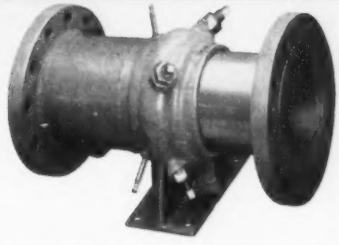
C. H. WHEELER MFG. CO.

19th and Lehigh Avenue • Philadelphia 32, Pennsylvania

Whenever you see the name C. H. Wheeler on a product, you know it's a quality product

Steam Condensers • Steam Jet Vacuum Equipment • Centrifugal, Axial and Mixed Flow Pumps • Marine Auxiliary Machinery • Nuclear Products

TWO QUALITY PRODUCTS TEAMED FOR AN EFFICIENT INSTALLATION



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GUN-PAKT
EXPANSION JOINTS

Write for free 36-page pocket reference booklet

Because there is no need to shut down for repacking, the Yarway Gun-Pakt is one of the most popular expansion joints used in modern steam distribution lines. The Yarway joint is built for long service, with never any danger of metal fatigue or failure.

There must be no failure at flanged connections, either. That's why Yarnall-Waring Co. uses Phoenix forged-steel flanges on Gun-Pakt expansion joints.

Like Yarnall-Waring, you, too, will find that *you can't buy better flanges*. May we demonstrate the advantages of Phoenix service?

Leading Manufacturers of Pipe and Tank Flanges and Commercial Forgings

PHOENIX

FLANGE AND FORGING DIVISION

PHOENIX MANUFACTURING COMPANY

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Avoid costly downtime from dirty process water

Clarify it with Celite filtration

PROCESS WATER which contains colloidal color and suspended solids may cause costly downtime or damage expensive plant equipment.

Celite* filtration prevents fouling of resin beds in softeners and demineralizers. It also assures clean, clear water for boiler feed, cooling towers, heat exchangers, scrubbing towers and other process operations where slime, sludge or mud deposits can cause serious trouble.

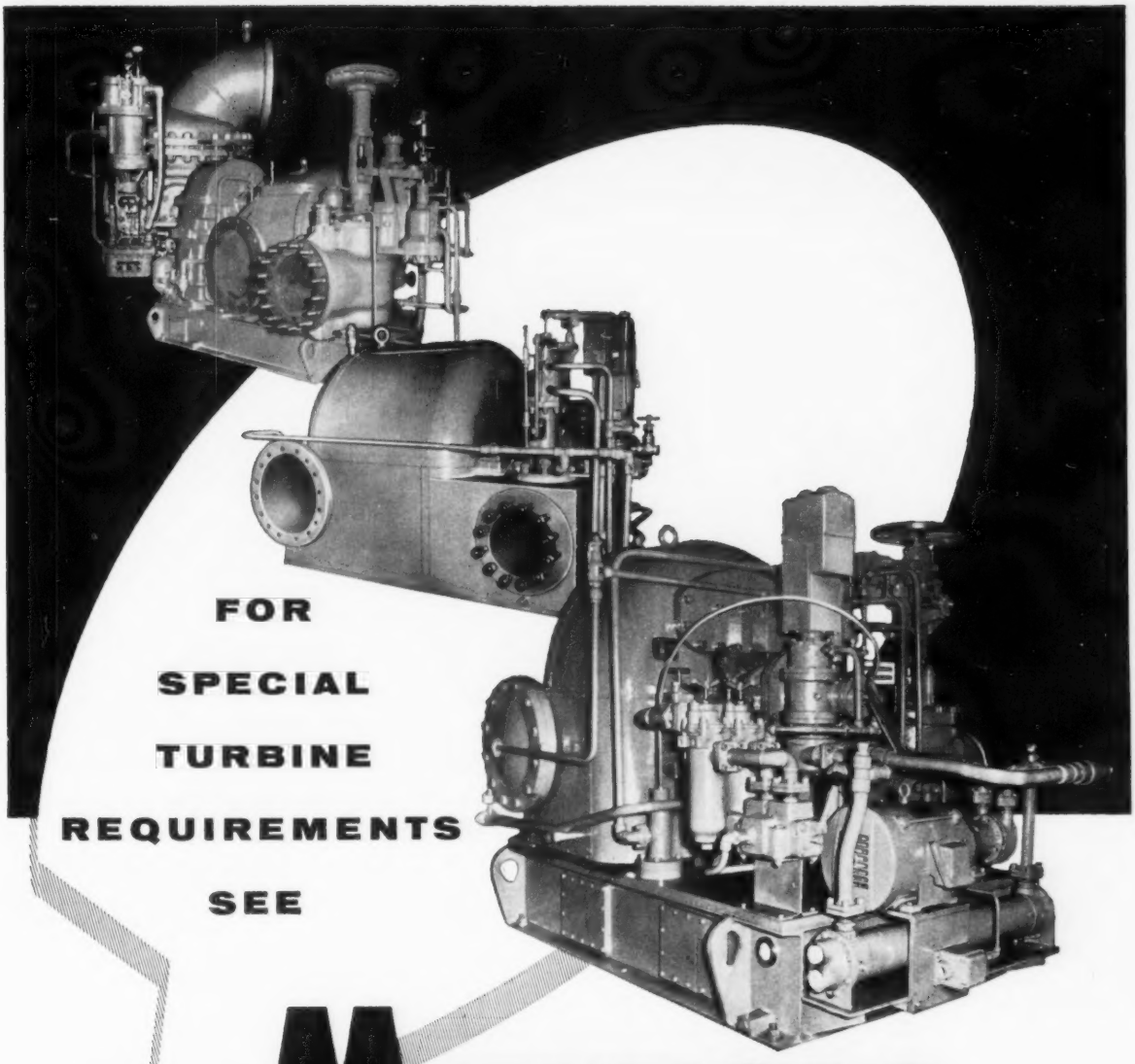
Celite removes more suspended solids than other types of clarification—even amoebae and algae and most bacteria if required. It operates at fast flow rates with any conventional pressure filter. It comes in 9 standard grades for precise clarity control. And it is low in cost.

A Celite engineer will be glad to study your water problem and offer his no-obligation recommendations. Write Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada, Port Credit, Ont.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CELITE diatomite filter aids



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Our nearest representative will help you solve your turbine requirements. His name gladly sent on request.

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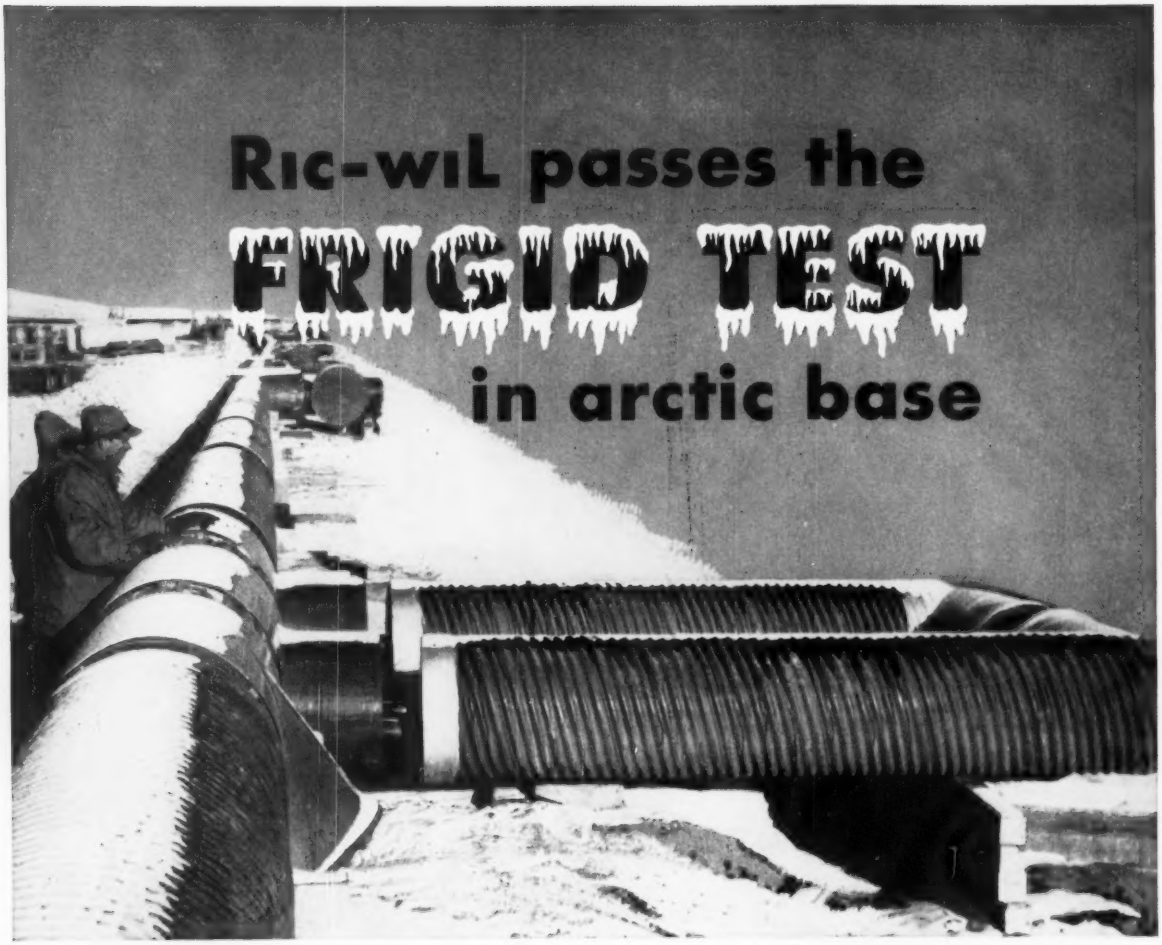
Builders of Steam Power Equipment for Nearly a Century



Photograph courtesy U. S. Army Engineers, Eastern Ocean District.

Architect—Alfred Hopkins Assoc., N. Y.
Engineers—Metcalf & Eddy, Boston, Mass. & Guy B. Panero, N. Y.
Contractors—North Atlantic Constructors, N. Y.

The task of building the multimillion dollar Thule Air Base in Greenland confronted the Army's Corps of Engineers with temperatures of 40° below zero.

A Ric-wiL prefabricated insulated system was selected for steam and return distribution lines to feed steam from 40 boilers at 12 different locations. After more than five years of operation the complete system has operated without breakdown. Personnel who man this defense outpost work and live in comfort comparable to stateside duty . . . truly a major accomplishment considering Arctic climatic conditions.

SEE OUR CATALOG IN SWEET'S ARCHITECTURAL FILE OR WRITE FOR COPY

Quality Piping Systems . . .
. . . of Exceptionally High Thermal Efficiency

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RIC·WIL INCORPORATED PREFABRICATED INSULATED PIPING SYSTEMS

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GET THE MOST FOR YOUR

BTU DOLLAR

...with Nicholson steam traps

You get top operating temperature per dollar of fuel consumption . . . when you use the Nicholson steam trap. This trap purges all air and non-condensibles from pipes and equipment *continuously* . . . not just at warm-up time. Your boiler doesn't have to operate at top capacity —all the time—to obtain top steam temperature where and when you need it.

Make full use of your BTU dollar, with Nicholson traps. They have only one moving part . . . a valve that operates on just a few degrees of temperature differential.

In your steam generation, and in your steam utilization . . . Nicholson traps will save you money. You can try one . . . without obligation! W. H. Nicholson and Company, 12 Oregon St., Wilkes-Barre, Pa. Sales and Engineering Offices in 98 principal cities.

NICHOLSON

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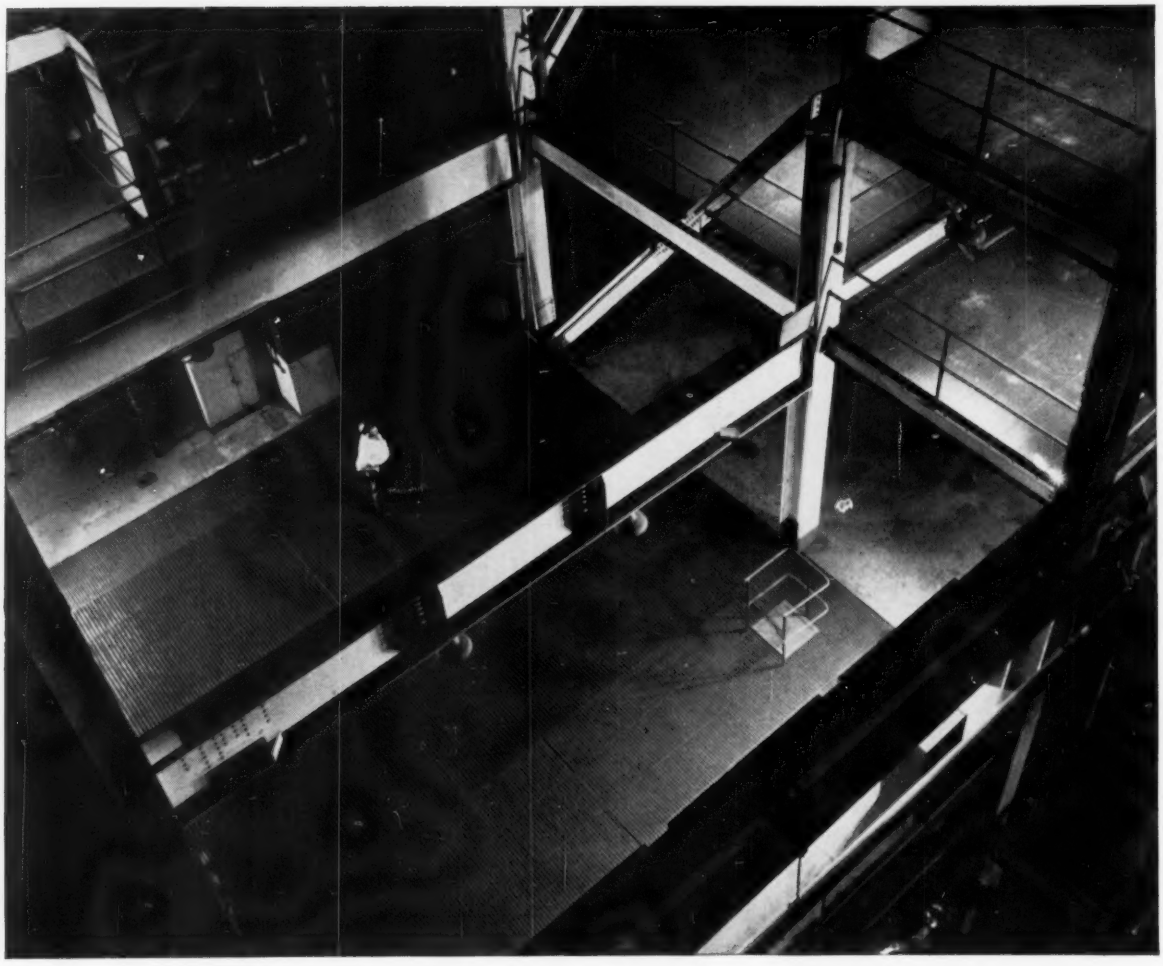

Blaw-Knox Electroforged® Steel Grating provides removable floors to simplify plant operation

Floors and mezzanines made of Blaw-Knox grating solve the problem of reaching, moving and servicing the largest types of equipment. Sections come up easily, allowing ample space to maneuver and maintain any size of machinery. Costly, time-consuming alterations are virtually eliminated.

For increased plant safety Blaw-Knox Electroforged Steel Grating provides rigid one-piece construction for sure support of the heavy loads. Non-slip cross bars and a wide variety of bearing bars assure safe walking and climbing — even under the most hazardous working conditions.

Because there's nothing to wear, or patch, nothing to catch and retain dirt, upkeep becomes easy and economical. And grating's maximum open area admits more air and light, makes brighter, better-ventilated plants.

Blaw-Knox Electroforged Steel Grating for walkways, stair treads and floors is fabricated to meet your specific operating needs. For new ideas about a complete line of space saving grating, write for Bulletin 2527 featuring grating and treads.

BLAW-KNOX

BLAW-KNOX COMPANY

Equipment Division
Dept. Y, Pittsburgh 38, Pennsylvania

POSITIVE, TIGHT
VALVE CLOSURE...
under all variations of Temperatures and Pressures

* Simple indicator always shows amount of compensating spring compression.

New TYPE SA LimiTorque WITH COMPENSATING SPRINGS

Correct seating of the valve is extremely important during automatic valve operation, especially where fluctuation of high line temperatures are encountered.

To assure an absolutely tight seat, the new LimiTorque Type SA Unit incorporates unique compensatory springs which, literally, "take up" any amount of contraction or expansion caused by decreasing or rising line temperature.

These springs of Belleville Disc type vary in number for use in either parallel or series, within fixed limits, to provide the desired compensation. The result of continual improvement and development, the Type "SA" LimiTorque contains all the features of the famous Type SMA unit plus a simple indicator to show the amount of compensating spring compression. Available in Weatherproof and Explosion proof construction, these units can be mounted on any size valve in almost any position.

For information and data, write for Bulletin 4-57.

features:

- Controlled thrust applied to valve operating parts.
- Greater torque, thrust and stem capacity.
- Easier handwheel operation.
- Two piece stem nut design permits changing unit from one valve to another.
- Torque control for both directions of stem travel or single direction as required.
- Lubricant sealed in for life of unit.
- Simple indicator which always indicates amount of compensating spring compression.

LimiTorque® — **PHILADELPHIA GEAR CORPORATION**

ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.

Offices in all Principal Cities

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

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Are You Preparing *Now* For The Next Boom?

America's leading companies are not sitting on their hands waiting for the recession to end. They are planning ahead ***now*** for higher sales and near-capacity rates of operation.

These facts stand out clearly from the eleventh annual survey of Business' Plans for New Plants and Equipment just completed by the McGraw-Hill Department of Economics:

- **Manufacturing companies expect their sales to increase 20%, on the average, from 1958 to 1961.** Growth industries, such as chemicals and electrical machinery, expect gains of 25% to 34%.
- **If these sales gains are achieved, the average rate of operations in manufacturing will rise from 78% at the end of 1957 to almost 85% by 1961.** This is the point at which pressure on costs begins to mount, as less efficient facilities are pressed into service.
- **Industry is not waiting for this point to begin getting its plants and equipment in shape for the next boom.** Despite record expansion in the past several years, many manufacturing companies plan to add new capacity in each of the next four years. But, more important, they are going ahead with the vital job of modernization and cost-cutting.

In the years immediately ahead almost two-thirds of capital investment will go for modernization and replacement of present plants and equipment. In this way manufacturing companies can avoid the higher costs and the squeeze on profits that occur when producing facilities are not in shape to handle an increase in sales volume.

These are the plans, as reported to McGraw-Hill, of a wide sample of manufacturing companies—for the most part, large firms and leaders in their respective industries. Altogether, these firms account for almost 40% of all employment in manufacturing industries.

Now Is The Time

How do your plans measure up? Are you planning ahead now for a 20% sales increase in the next three years? Is your company planning to modernize its buildings and equipment more rapidly than at any time in the recent past? If not, here are some of the inducements

that McGraw-Hill editors report from their continuous checking on the state of business.

(1) **There are plenty of opportunities for increasing efficiency by the installation of new equipment and the improvement of layouts in plants, warehouses and offices.** Despite the installation of tremendous volumes of metalworking equipment in recent years, according to AMERICAN MACHINIST over half of the machine tools now in U. S. factories are over 10 years old. Replacement of worn-out and obsolete equipment will mean material savings in operating and maintenance costs.

(2) **Machinery, parts, materials and labor are much more readily available now than they are when the economy is running at full steam.** You can be more particular about quality and about specification to meet your own requirements.

(3) **With lower interest rates and less competition for loans, it is both easier and cheaper to borrow money to finance equipment and construction.** To wait for another boom is to run the risk of having to pay higher interest rates and look harder for money.

(4) **Although there is an adequate supply of most types of labor available now, the prospect is that the supply of factory labor over the years ahead will be tight.** In 1965, there will actually be fewer men and women between the ages of 25 and 44 than there are now. Good factory workers will be either hard to get, or wage rates will rise sharply or—more likely—both. The best answer is to anticipate the rise in labor costs by installing more efficient equipment to increase labor productivity.

(5) **Finally, the costs of investing in new buildings and improved equipment *now* are almost surely less than they will be later.**

These are some of the reasons why many leading firms find ***now*** the best time in years to start on a program of plant modernization. There are other good reasons in the many new products and processes coming from the boom in research and development. This year industry will spend over $8 billion on R & D—$1 billion more than in 1957. And a heavy share of the new product development will consist of better machines and processes to be made available during the next few years. Already the pace of technical advance is so rapid as to call for modernization of plants built only a few years ago.

Years of Opportunity

It has been said that the years between now and 1961 are the "middle years" between two booms. This does not mean a long period of recession, but a period of slower growth—a transition from the postwar boom based on deferred demand, to a new boom in the 1960s based on dynamic population growth and a revolution in technology.

If so, these are the years of opportunity for business—opportunity to prepare for the growth that lies ahead with the most efficient equipment, the most modern plant and the best production organization that can be devised. This is the way to fight higher costs and avert a resumption of inflation. This is also the way to ensure that your company will be ready for its new markets in the 1960s.

Are you planning ahead ***now*** to be among the leaders?

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

Donald C. McGraw
PRESIDENT

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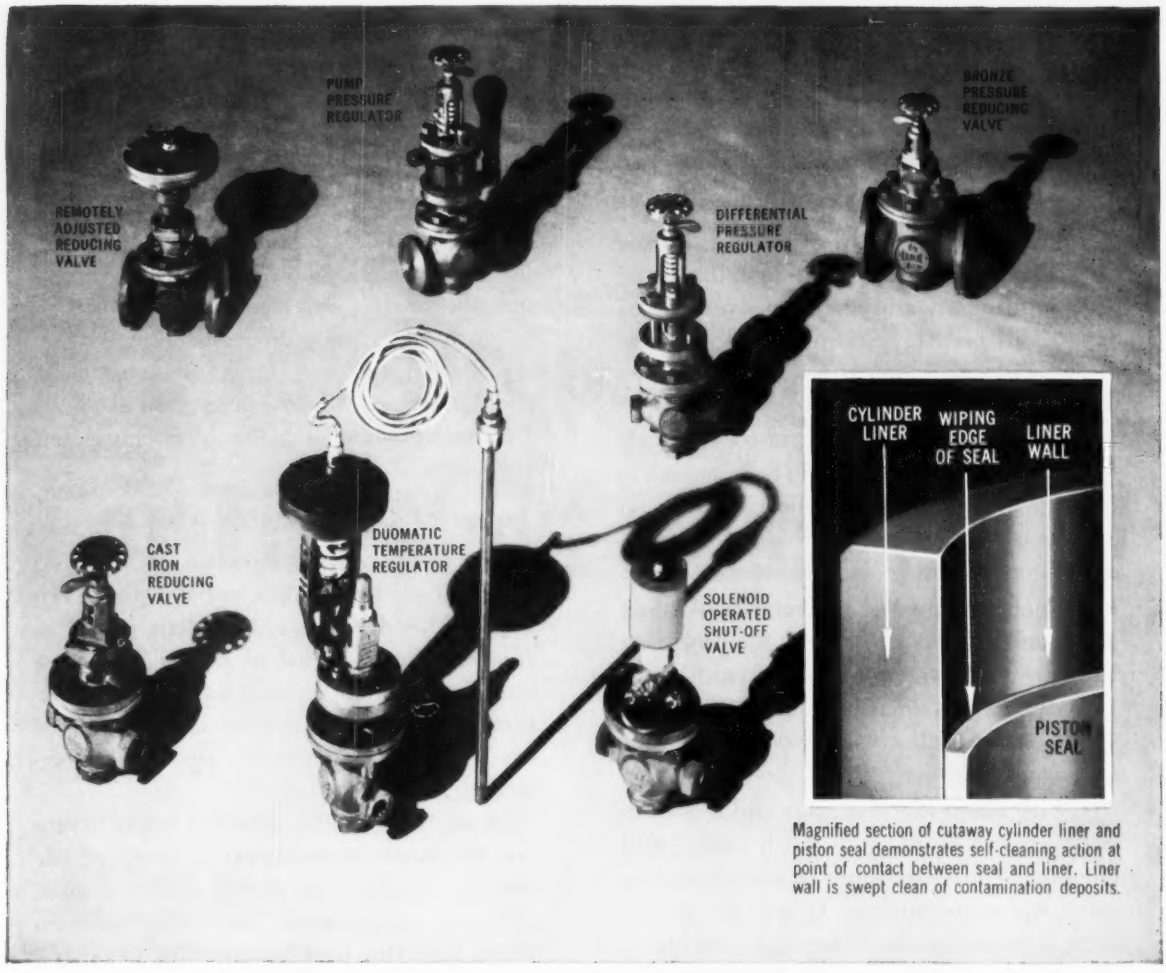


Magnified section of cutaway cylinder liner and piston seal demonstrates self-cleaning action at point of contact between seal and liner. Liner wall is swept clean of contamination deposits.

. . . another LESLIE Quality First!

REGULATORS WITH SELF-CLEANING PISTONS

. . . at no extra cost

Now it can be told! After 3 years of exhaustive field tests and over 5,000 installations, Leslie announces the standardization of exclusive self-cleaning, pressure sealing pistons for reducing valves, temperature and pressure regulators in ½ to 6″ sizes — another Leslie FIRST!

Continuous Wiping Action

The continuous "wiper" action of the new piston's seal keeps the cylinder liner clean, improves reliability, reduces maintenance.

The molded self-lubricating piston seal has already proved itself in high temperature service up to 500°F.

Reduces Wear and Sticking

The resilient cushion between the piston and cylinder liner reduces wear and eliminates "freezing" or sticking of these parts. The self-lubrication and pressure-sealing of the new piston insures smooth, dependable operation even in the toughest applications and where long standby periods are a problem with ordinary regulators.

Fully Interchangeable in Field

You can have this desirable new Leslie FIRST in *any* piston-operated Leslie regulator now in steam service for all temperatures up to 500°F. A quick conversion kit is available and your present Leslie Regulator can have the new seal added in a matter of minutes.

More Information

More data is available — send for these aids without obligation.

Data Sheet RV-51C — Instructions for converting your present Leslie Regulator to self-cleaning piston type
Bulletin 5302-B — Reducing Valves and Pressure Regulators
Bulletin 5307-A — Temperature Regulators

Or ask to see a demonstration model of the new pressure seal piston.

LESLIE REGULATORS and CONTROLLERS

LESLIE CO., 235 Grant Avenue, Lyndhurst, New Jersey

Consulting Engineers: Seelye, Stevenson, Value & Knecht. Heating Contractors: Almirall & Co., Inc. and Norman Heating Co., Inc.; Eugene J. Brandt & Co., Inc.

LARGE TRENCH AT IDLEWILD shows one expansion loop in foreground and another in background. Note large pipes for chilled water lines running outside of the walled trench containing the high temperature hot water system. The control tower is in the center of the photograph, and the new International Arrival Building is at the right of the tower. The bags of GILSULATE are slid down boards into the trench.

$90,000,000 Idlewild expansion program uses 1515 tons of GILSULATE to protect 7 miles of pipe

New York International Airport Has One of World's Largest High Temperature Hot Water Systems

By 1960 "Terminal City" will be a completed reality at New York International Airport. This gigantic undertaking comprises 655 acres and will be equipped to handle 140 aircraft at one time. Estimated cost of the project is $90,000,000.

Running from a central heating plant to each of the projected buildings in Terminal City is one of the world's largest non-military high temperature hot water systems ever designed. This system, operating at 380°F on the supply and 240°F on the return lines, includes 38,774 feet of pipe (7.34 miles!), virtually all of which is protected with 1515 tons of Type B GILSULATE. In this gigantic system, expansion loops alone total almost one mile!

Big job or small job, GILSULATE offers the same unique protection for underground hot pipes—and the same opportunity for on-the-job savings. GILSULATE is easy to install; it calls for no trained fitters or applicators, no special installing equipment. So whether *your* piping job is large or small, you'll find that GILSULATE fits right into your specification picture—at a lower cost per installed linear foot than any other underground hot pipe insulation.

For more complete information, see your local GILSULATE distributor, or write any of our offices listed below.

AMERICAN GILSONITE COMPANY
SALT LAKE CITY 1, UTAH

Affiliate of Barber Oil Corp. & Standard Oil Co. of Cal. OFFICES AT: 134 West Broadway, Salt Lake City, Utah. The agents Building, 3537 Lee Road, Cleveland 20, O.

Distributors in principal countries of the world

Do you receive PIPE INSULATION NEWS? Ask to be put on our mailing list.

Artist's sketch of Terminal City showing proposed buildings and extent of high temperature hot water system.

FACTS ABOUT GILSULATE

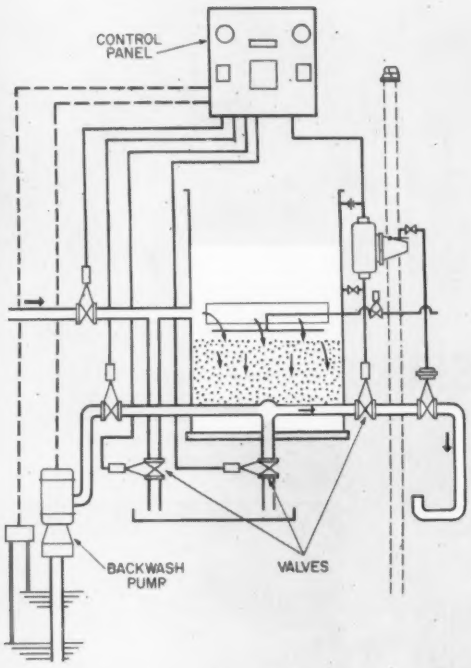
1. **EASY TO USE**—just pour and tamp...pipe heat does the rest.
2. **FORMS 3 ZONES** of protection against heat loss and all hazards commonly encountered by buried hot pipes.
3. **NEEDS NO HOUSING OR MECHANICAL SHEATHS:** no mixing, special handling or equipment.
4. **ONLY NEEDS NORMAL PIPE SPACING:** for multiple pipe or cramped conditions.
5. **THREE TYPES AVAILABLE:**
   Type A for 220°-300°F. temp. range
   Type B for 300°-385°F. temp. range
   Type C for 385°-520°F. temp. range

GILSULATE®

The Triple-Zone Insulation System for Lifetime Protection of Underground Hot Pipes

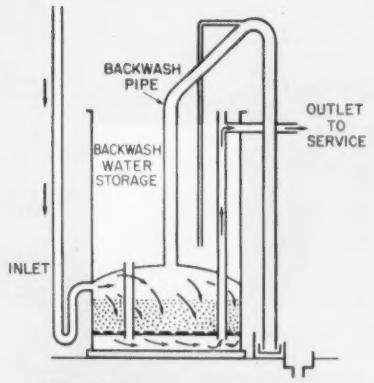
CONVENTIONAL gravity filter and hydraulic controls for automatic operation. Approximate installed cost of a unit that will filter 500,000 gallons per day:

$21,700.00



NEW PERMUTIT VALVELESS Gravity Filter. Completely automatic operation. Approximate installed cost of a 500,000 gpd unit:

$11,900.00



HOW IT WORKS: As dirt collects on the sand, increased head pressure slowly raises the water level in the large backwash pipe. See diagram. When it spills into the downward section of the pipe, it starts a siphon (backwash) flow that draws water down from the Storage area and up through the sand, "floating" dirt off to waste. When backwash water is gone, air enters the small tube and stops the siphon. Flow through the sand reverses and the first filtered water (rinse water) goes to Storage area until full. All flow then runs to Service.

New Valveless Water Filter Saves $$ for Industries, Cities, Electric Companies

• Big water users like city water departments, steam stations, refineries, chemical plants and paper mills can substantially reduce the cost of their water-conditioning equipment and its operation and maintenance . . . by adopting a new automatic Valveless Filter developed by engineers of the Permutit Company (N. Y.).

The simplified design makes ingenious use of the siphon and other hydraulic principles to replace expensive valves, flow controllers, pumps and hydraulic or pneumatic control systems. The design also prevents wasteful, excessive use of water for backwashing or rinsing. Tanks are shipped set-up to reduce installation costs. The absence of moving parts virtually eliminates maintenance costs.

The Valveless Filter produces uniform, high-quality water. It cannot be "forced." Backwashing or rinsing cannot be too little or too late . . . or accidentally run to Service. And the filter cannot develop common troubles like "cracked" or "upset" beds, "channeling" or "mudballs."

Single Valveless Filters or multiple units for any volume requirement are available. Present installations include units for industrial plants treating water for both process and drinking.

Send for free descriptive bulletin. Address: The Permutit Company, Dept. P-6, 50 West 44th St., New York 36, N. Y. or The Permutit Company of Canada, Ltd., Toronto 1, Ontario.

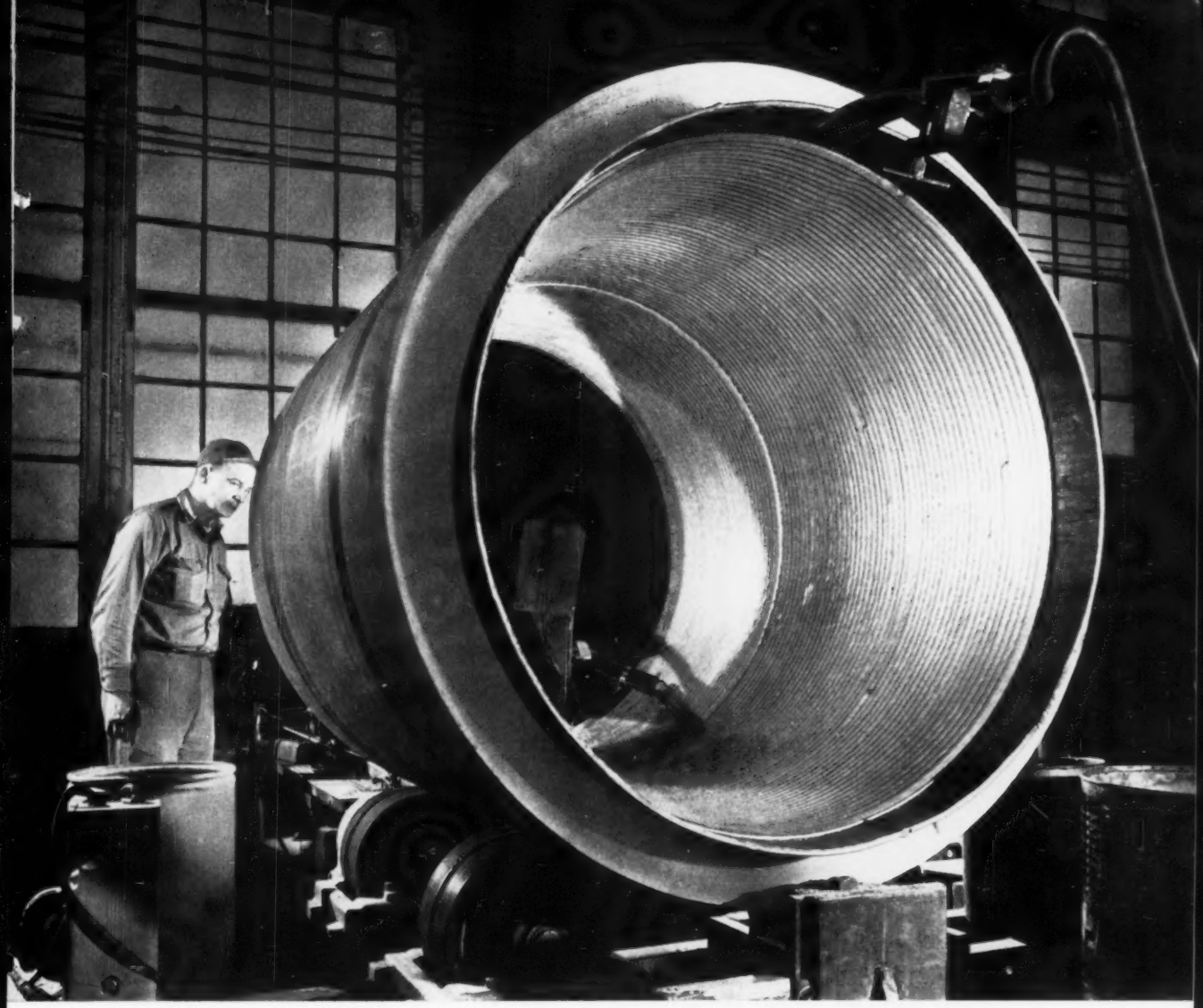
PERMUTIT®

rhymes with "compute it"

a division of PFAUDLER PERMUTIT INC.

Water Conditioning

Ion Exchange • Industrial Water Treatment



Cylinder for ALCO *nuclear pressurizer is overlay-welded with stainless steel. Pressure vessel meets stringent Navy specifications for nuclear components.*

THE NEW DEFENSE AGAINST CORROSION

Pressure vessels in nuclear plants operate under highly corrosive conditions. Solid stainless-steel construction resists this corrosion, but the cost is very high. Now ALCO has developed a welding technique that clads the inside of non-stainless nuclear vessels with stainless steel—providing the same resistance to corrosion, but at less cost.

This new development is being used on ALCO-built pressure vessels for various nuclear programs. The stainless steel is welded to the interior of a high-strength cylinder forged by ALCO. After the stainless surface is machined, a seam-free, corrosion-resistant vessel results.

In this particular product, ALCO has complete control of quality—from steel-making through forging, overlay-welding and final fabrication. Unique experience and facilities like this have made ALCO a leader in building components for almost every nuclear project to date.

Information on ALCO nuclear and thermal equipment is available at your nearest ALCO sales office, or write ALCO Products, Inc., Department 136, Schenectady, New York.

ALCO

ALCO PRODUCTS, INC.

NEW YORK

SALES OFFICES IN PRINCIPAL CITIES

Locomotives · Diesel Engines · Nuclear Reactors · Heat Exchangers · Springs · Steel Pipe · Forgings · Weldments · Oil-Field Equipment

Main steam, boiler feed and miscellaneous piping for the nation's first full-scale commercial atomic power plant.

Dravo piping at Shippingport

Fabricating and installing piping for the Shippingport nuclear power plant presented many unusual problems. Specifications were extremely demanding and new techniques had to be employed.

In Dravo's Marietta shops, more than 3700 welds were made on stainless steel, aluminum, and carbon steel piping, ranging in size from 3″ to 12″ diameter. Many more thousands of welds were made at the site and all were thoroughly inspected and tested to assure performance under exacting conditions.

Each of the piping systems was hydrostatically tested at 1½ times the operating pressures. All of the butt welds and 99.9% of the more than 11,000 socket welds were leakproof on the first test.

Fabricating and installing this piping for the nation's first full-scale commercial atomic power plant demonstrates Dravo's ability to handle piping projects of all types. A letter will bring full information on pipe fabrication and erection facilities—write Dravo Corporation, Pittsburgh 22, Pa.

View of the Shippingport Atomic Power Station which was built as a joint venture by the U. S. Atomic Energy Commission and the Duquesne Light Company. Westinghouse Electric Corporation developed the nuclear components of Shippingport under a contract with the AEC. Duquesne Light Company is operating the station. As a sub-contractor to Westinghouse, Dravo fabricated and installed more than 10 miles of piping at Shippingport.

DRAVO
CORPORATION

Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

CLAY ELECTRIC CO-OPERATIVE, INC.:

R E A Project in Keystone, Florida, operating four Cooper-Bessemer engines on No. 6 fuel oil since 1954.

"De Laval Heavy Oil Purifiers SAVE US $72,000 ANNUALLY."

Robert J. Dodd, *Chief Engineer*, Clay Electric Co-Operative, Inc.

"Since we converted to residual fuel operation with De Laval Heavy Oil Purifiers in 1954, we have saved a total of $288,987.59 . . . an average of $72,000 annually. Purification of No. 6 oil is so complete that maintenance costs for our Cooper-Bessemers are no higher than if we were using No. 2 fuel oil. The enclosed chart* shows yearly KWH output and fuel savings for the four years we've been operating on heavy fuel oil. It speaks for itself . . . conclusive proof of the economy of converting to heavy fuel processed through De Laval Purifiers."

*	KWH Produced	Savings Effected by Using Residual Fuel
1954	31,030,000	$ 95,228.27
1955	32,456,000	84,804.52
1956	27,866,000	57,727.81
1957	22,441,000	51,226.99
TOTALS	113,793,000	$288,987.59
AVERAGE	28,448,000	72,246.89

So writes Mr. Dodd. Compare his output and costs with your own. Calculate how much you can save in your own plant by conversion to heavy fuel operation . . . substantial savings made possible by De Laval Heavy Oil Purifiers. For further information, write for Bulletins S. A959 and S. A957. Better still, discuss heavy fuel conversion with your local De Laval representative.

DE LAVAL SEPARATOR COMPANY

THE DE LAVAL SEPARATOR COMPANY
Poughkeepsie, New York
or 427 Randolph Street, Chicago 6, Illinois

DE LAVAL PACIFIC COMPANY,
201 E. Millbrae Avenue, Millbrae, Calif.

THE CITY THAT DIDN'T EXIST A MONTH AGO

Every 30 days the U. S. adds as many new Americans as live in Norfolk, Va.—creating brand-new wants and needs which must be satisfied.

What does this mean to you? It means greater opportunities than ever before—in all fields. Home construction is expected to double by 1975. Power companies plan to increase output 250% in the next 20 years to provide the power for scores of new labor-saving devices. Clothing suppliers predict a one-third increase in 7 years.

With 11,000 new citizen-consumers born every day, there's a new wave of opportunity coming.

7 BIG REASONS FOR CONFIDENCE IN AMERICA'S FUTURE

1. **More people** . . . Four million babies yearly. U. S. population has *doubled* in last 50 years! And our prosperity curve has always followed our population curve.
2. **More jobs** . . . Though employment in some areas has fallen off, there are *15 million* more jobs than in 1939—and there will be *22 million more* in 1975 than today.
3. **More income** . . . Family income after taxes is at an all-time high of $5300—is expected to pass $7000 by 1975.
4. **More production** . . . U. S. production *doubles* every 20 years. We will require millions more people to make, sell and distribute our products.
5. **More savings** . . . Individual savings are at highest level ever—*$340 billion*—a record amount available for spending.
6. **More research** . . . *$10 billion* spent each year will pay off in more jobs, better living, whole new industries.
7. **More needs** . . . In the next few years we will need *$500 billion* worth of schools, highways, homes, durable equipment. Meeting these needs will create new opportunities for everyone.

Add them up and you have the makings of another big upswing. Wise planners, builders and buyers will act *now* to get ready for it.

FREE! Send for this new 24-page illustrated booklet, "Your Great Future in a Growing America." Every American should know these facts. Drop a card today to: ADVERTISING COUNCIL, Box 10, Midtown Station, New York 18, N. Y.

(This space contributed as a public service by this magazine.)

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Featuring additional products specialties and services for power plants

TO manufacturers of equipment and those offering special services to the power industry, this section offers an inexpensive means of keeping products or services regularly before your potential customers—the readers of POWER. The small spaces available here provide opportunity for you to be represented in every issue at low cost. Can we serve you?

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"By reason of special training, wide experience and tested ability, coupled with professional integrity, the consulting engineer brings to his client detached engineering and economic advice that rise above local limitations and encompasses the availability of all modern developments in the fields where he practices as an expert. His services, which do not replace but supplement and broaden those of regularly employed personnel, are justified on the ground that he saves his client more than he costs him."

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(Classified Advertising)

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An advertising inch is measured ⅞" vertically on one column, 3 columns—30 inches—to a page.

Send New Ads to Class. Adv. of Power, P.O. Box 12, N.Y. 36, for July Issue closing June 6th.

ADDRESS BOX NO. REPLIES TO: Box No.
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Send to office nearest you.
NEW YORK 36: P. O. BOX 12
CHICAGO 11: 520 N. Michigan Ave.
SAN FRANCISCO 4: 68 Post St.

POSITIONS WANTED

Power Plant Superintendent, age 36, technical education, 12 years experience in the operation, maintenance and plant betterment of turbo-electric power plants. PW-6856, Power.

Power Plant Engineer, age 41, married, technical education, 16 years in field, 2 years assistant shift supervisor in operation large, modern, high pressure steam-electric generating station. Extensive marine operating and maintenance experience. Some refrigeration, air conditioning and diesel experience. Will consider foreign assignment. PW-7533, Power.

SELLING OPPORTUNITY OFFERED

Wanted: Manufacturer's representative to sell our line of high-quality molded long fiber asbestos-rubber gaskets both for original equipment and replacement sales. Need aggressive individual in Chicago, Illinois; Philadelphia, Pennsylvania; Cleveland, Ohio; St. Louis, Missouri; Los Angeles, California; Pittsburgh, Pennsylvania; Boston, Massachusetts; New York City, or Metropolitan Newark, New Jersey. RW-7957, Power.

FOR BRITAIN

• ENGINEERS • PHYSICISTS • • MATHEMATICIANS •

The English Electric Company of England is actively engaged in the design and construction of the largest Atomic Power Station in the world. This is one of the few commercially sound Nuclear Power Stations now being built for the generation of electrical power.

Engineers, physicists & mathematicians who are interested in this work or who are interested in being trained for such work are invited to send details of their experience and qualifications to the address given below.

It must be stressed that these interesting openings are intended for people with the highest academic and technical qualifications.

Selected applicants will be interviewed by the Chief Engineer of the Atomic Power Division of the English Electric Company at centers in the United States during June and at these interviews full details will be given of the salaries, excellent conditions of employment and additional allowances to make this work in Britain an outstanding opportunity.

Send resume to Mr. Stanley Dean

THE ENGLISH ELECTRIC COMPANY LIMITED

23-25 Beaver Street • New York 4, New York

WANTED BY USER

3000 KW turbine-generator, 600 lbs. 750 degrees, automatic extraction, 15 to 25 lbs. condensing. Preferable voltage on generator 3 phase 2300/4160 volts. Full particulars will be treated confidentially if desired.

W-8043 POWER
520 N. Michigan Ave., Chicago 11, Ill.

WANTED

Complete power plants, turbo generators, Boilers, Condensers, Engine generators, Processing Plants and equipment.

PAUL OBERMAN
1910 Delmar St. Louis, Mo.

ELECTRICAL ENGINEER

Excellent opportunity for Electrical Engineer 28 to 35 years of age, who has a college degree and some industrial experience to locate with large paper manufacturer in northern New England. Work includes design layout for the installation of all types of electrical equipment, electrical repairs and new construction. Will work under supervision of department head. Salary will reflect previous experience.

P-7707, POWER
Class. Adv. Div. P.O. Box 12, N.Y. 36, N.Y.

WANTED ASSISTANT POWER ENGINEER

For new gas turbo-generator plant. Must be thoroughly experienced in operation and maintenance of all power plant equipment, including boilers, turbo-generators, switchgear, and auxiliaries. Prefer man in his thirties or early forties with pulp and paper mill power plant experience, or similar. Location south.

P-7629 POWER
620 North Michigan Ave., Chicago 11, Ill.

WE PAY
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FOR
Electric Motors • Starters • Transformers
Electric Supplies
ALLIED ELECTRIC CO.
710 N. MAIN ST., MEMPHIS, TENN.
BOX 1838—PHONE JA 7-1681

WANTED:— TRANSFORMER

One 5000 KVA, 57 KV Delta/2,300 volt Delta, 3 phase, 60 cycle, oil filled, air cooled, transformer, with 2-2½% Taps above and below. 7.27% Z. Provision for future fans desirable.

W-7465 POWER
68 Post Street, San Francisco 4, Calif.

GENERATING PLANT SUPERINTENDENT:

Midwestern Cooperative wants operating superintendent to take full charge of steam plant. Permanent position, excellent conditions, many fringe benefits. Give full particulars of qualifications and experience in first letter. Must be prepared to start work July 1st, at latest.

Write P-7702 POWER
520 N. MICHIGAN AVENUE, CHICAGO 11, ILL.

FOR SALE
ONE SKINNER UNIFLOW ENGINE

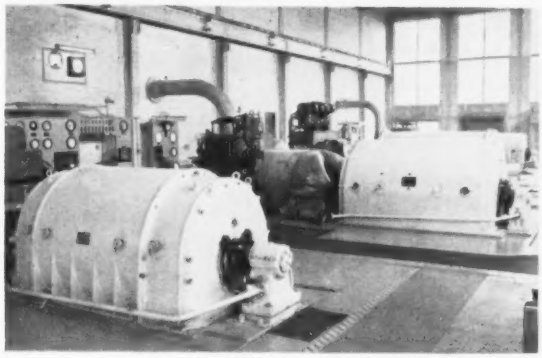
With 50 KW, 240 volts, 3 phase, 60 cycle, GE AC generator with control panel and Westinghouse surface condenser and airejector.

UNIVERSITY OF UTAH
MECHANICAL ENGINEERING DEPARTMENT
SALT LAKE CITY, UTAH

GET CASH NOW
for your new surplus motors, controls and transformers!
AVAILABLE: NEW MOTORS
Write, wire or phone collect!
AJAX ELECTRIC MOTOR CORP.

SPECIAL OFFERING!

650 lb., 725 DEG TURBO GENERATORS — Still on Original Foundations As Shown in Photo Below — All Westinghouse, 3600 RPM, 80% P.F., 6900 V, 3/60.



1—9375 KVA, 7500 KW, 125 P.S.I.G. auto extraction, surface condenser, installed in 1937.
1—9375 KVA, 7500 KW, non-condensing, 125# B.P., installed 1930.
1—6250 KVA, 5000 KW, Condensing, with surface condenser, installed 1942.

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BELYEA CO. INC.

43 HOWELL STREET — JERSEY CITY 6, N. J.

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FOR SALE
15 NEW TURBINES

4 horizontal, 11 vertical, Westinghouse

Driving forced draft blowers—capacities ranging from 39000 to 56000 CFM and 16" to 24" pressure. Steam pressures 360 to 575#, back pressure 10#.

Will sell turbines separately if desired. *Price reasonable.*

Also—1—250 KW GE turbo generator unit, 3 phase, 60 cycle, 440 volt. Used one year.

G. M. De ROSE
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BARGAIN OPPORTUNITY

600 HP—720 RPM, General Motors Model 567 Electro Motive Diesel engine direct connected to a:

500 KVA—400 KW at 80% PF, 720 RPM, 3 phase 60 cycle, 480 volt Westinghouse alternating current generator.

Complete installation. Equivalent to new.

EUCLID ENGINEERING CORP.
609 National City E. Sixth Building
Cleveland 14, Ohio

FOR SALE

STEAM BOILERS

2—18000 lbs./Hr. Heine 175 psi, straight tube, oil fired, 1920
3—21000 lbs./Hr. Combustion Engr. 200 psi, Stoker fired, 1938
1—30,000 lbs./Hr. Combustion Engr. 450 psi, 825° stoker fired, 1950

SURFACE CONDENSER

1—2500 Sq. Ft Westinghouse, 2 Pass, with aux., 1950

DIRECT CURRENT GENERATOR

1—250 KW, Westinghouse, 250V, 720 RPM, 1950

MOTOR GENERATOR SET

1—25 KW, Westinghouse, 250V DC, 208 120V AC, 1800 RPM, 1950

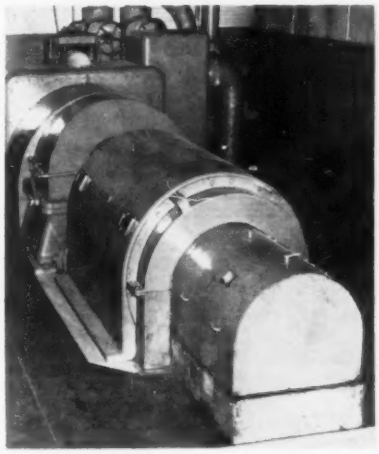
WATER PUMPS

1—14000 GPM @, 370' Hd. De Laval Centrifugal, 690 RPM, 1800 HP, 1920
1—20800 GPM, @, 370' Hd. De Laval Centrifugal, 720 RPM, 2500 HP, 1949
1—24500 GPM @, 370' Hd. Worthington Centrifugal, 950 RPM, 3200 HP, 1954

STEAM TURBINES

1—1800 HP, De Laval Condensing, 165 lbs. psi 3600/690 RPM, 1920
1—2500 HP, De Laval Condensing, 400 lbs. psi 3600/720 RPM, 1949
1—3200 HP, Worthington Condensing, 175 lbs. psi 3600/950 RPM, 1954

INTERNATIONAL POWER MACHINERY CO.
1612 Union Commerce Bldg.
Cleveland 14, Ohio — Main 1-9514



2500 KVA POWER PLANT. Will be sold individually or as a complete unit. **TURBINE** — 9 Stage, Non-Condensing, Automatic Extraction, 600 PSIG, 600° FTT, 150# Extraction, 30# Back Pressure, 3600 RPM, direct connected to **GENERATOR**—2000 KW 3/60/480 Volts complete with Controls. **BOILER** — 4 Drum Bent Tube, 75000 #/hr. 650 PSIG, 650° FTT with Water Walls, Oil Fired complete with Fans Feed Water Pump and Deaerating Heater. **PRINTS** and Photos available. Write **HEAT & POWER CO., INC., POWER EQUIPMENT DIVISION,** 60 E. 42nd St., New York 17, N. Y.

DIESEL ENGINES — POWER MACHINERY

100 KW to 1500 KW
Diesel Generator Sets • Stationary • Portable • Mobile Motors and Generators

A. G. SCHOONMAKER COMPANY, INC.

MAIN OFFICE: Box 516, Sausalito, Calif. EDgewater 2-1490
BRANCH: 50 Church St., N. Y. 7, N. Y. Digby 9-4350

CHECK WITH WAGNER FIRST!

Thousands of new and "Certified Rebuilt" Motors & Generators in stock—up to 1000 H.P. OUR 52nd YEAR

A. C. MOTORS—60 CYCLE

HP	Mfr.	Type	Volts	Speed
800	Whse. (2)	Sq. Cage	2300	1800
700	Whse.	Slipring	2300/4000	1200
500	G.E.	Slipring	2200/440	600
500	Whse.	Slipring	2200	450
400	Whse. (2)	Synch.	2200	1800
400	Whse.	Sq. Cage	2200	514
400	Marathon (2)	Sq. Cage	2200	3600
400	Whse.	Sq. Cage	2300	900
400	G.E. (2)	Slipring	440	900
400	G.E.	Slipring	2300	514
350	G.E.	Sq. Cage	2200	1800
350	Cont. b.b.	Slipring	2300	900
350	G.E.	Slipring	440	1200
350	Allis Ch.	Slipring	2200/4000	600
300	El.Machy (2)	Synch.	2200/440	720
300	G.E.	Slipring	2200/440	600
300	G.E. (2)	Synch.	2200/440	360
300	Whse.	Synch.	440	1200
250	G.E.	Sq. Cage	2200/440	1200
250	Gen. Elec.	Sq. Cage	440	3600
250	G.E.	Slipring	220/440	720
250	G.E.	Sq. Cage	2200	1800
225	G.E.	Synch.	220/440	900
200	L.A. TEFC	Sq. Cage	440	1200
200	G.E.	Slipring	2200	900
200	Reliance b.b.	Sq. Cage	220/440	1800
200	Allis Ch.	Slipring	440	450
200	Allis Ch.	Slipring	2200/440	720
200	Whse.	Sq. Cage	2200/440	900
175	G.E. (2)	Synch.	220/440	720
150	Rel. TEFC	Sq. Cage	220/440	900
150	G.E. (4)	Slipring	2200/440	600
150	Cr. Wheeler	Sq. Cage	220/440	450
150	G.E.	Slipring	220/440	450
150	G.E. (2)	Sq. Cage	2200/440	1800
125	G.E. TEFC	Sq. Cage	2200	3600
125	Ideal	Slipring	4000/2200	900
125	Al. Ch. TEFC	Sq. Cage	220/440	600
100	Whse. TEFC	Sq. Cage	220/440	900
100	Smith b.b. (6)	Sq. Cage	220/440	1800

D. C. GENERATORS

KW	Mfr.	Type	Volts	Speed
200	G.E. b.b.	CD	250	1800
150	Whse.	SK-184	250	1150
150	Cr. Wh.	CCD	250	650
125	Gen. Elec.	CD	250	1150
100	Allis Ch.	E	125	1200
100	Reliance	651-T	600	1200
75	Gen. Elec.	CD-123	125/250	1200
60	Allis Ch. (3)	E-146	250	1500
60	Ideal	D	125	1150
25	Whse.	SK-103	250	1750

D. C. MOTORS

HP	Mfr.	Type	Volts	Speed
200	G.E. b.b.	CY-290	230	1750
170	Cr. Wh.	151-H	230	500
150	Whse.	SK-184	230	850
150	Whse.	SK-210	230	320/1000
125	G.E.	CD-173	230	575/1150
100	Reliance	651-T	550	1000/1800
100	Elliott b.b. T.E.	JH-FE	230	1150
60	G.E. TEFC b.b.	CD-135	230	1150
50	G.E. b.b.	CD-1238	230	500/1500
50	Century	DN-514	230	1150/1750
50	Gen. Elec.	CD-95	230	1800
50	G.E.	CD-125	230	400/1200
50	G.E.	RF-16	230	250/1000
40	G.E. (2)	CD-93	230	1750
25	Whse. (2)	SK-153	230	300/1200

MOTOR-GENERATOR SETS

KW	Mfr.	Input V	Output V
600	Allis Ch.	440 AC	250 DC
200	Gen. Elec.*	220/440 AC	125 DC
200	G.E.	2200/440 AC	600 DC
175	Gen. Elec.	220/440 AC	250 DC
125	Gen. Elec.*	2300/4000 AC	250 DC
100	Gen. Elec.*(2)	220/440 AC	250 DC
75	Gen. Elec.	220/440 AC	250 DC
75	G.E.	220/440 AC	125 DC
60	Allis Ch.	220/440 AC	250 DC
50	Cr. Wh. b.b. (2)	220/440 AC	250 DC

Arthur Wagner Co. Certified

MO nroe 6-7409

1435 W. RANDOLPH ST

CHICAGO 7, ILLINOIS

TRANSFORMERS—60 CYCLE

Qu	KVA	Make	Type	Phase	Voltages
2	3000	Mal.	Tr'R	3	7200/6600-4160/2400
2	750	G.E.	K	1	4600-120/240
1	750	G.E.	ET	3	4150Y-208/416
1	600	West.	Power Ctr.	3	2400-120/240/480
3	500	West.	SL		4800/2400-240/480
1	300	West.	Power Ctr.	3	2400/4160Y/240-480
1	300	Penna.	(Askarel)	3	12470Y/7200-240
2	250	G.E.	H Pyranol	1	4800/8320Y/120/240
2	250	West.		1	2300/4600-230/460
1	225	Kuhlman	OISC Furn.	1	440-100
3	200	G.E.	H	1	7800-15600-220/440
1	150	Elsler	OA	1	4160-240/480
3	100	West.	(Air) VR	1	480/240-240/120
3	100	G.E.	H		2400/4160-240/480
3	50	G.E.	HS	1	2400/4160/240/120
1	50	Amer.	Abestol	3	4160-120/208Y
5	50	G.E.	HS	1	2400/4160-240/480
3	37½	West.	(Air) VR	1	480/240-240/120
3	37½	West.	S	1	2400/4160Y/120/240
4	25	West.	Hypersil	1	2400/4160-120/240
3	15	West.	H Pyranol	1	6900/11950Y-120/240
7	7½	Electran	(Air) Furn.	1	460-8/40

MOTOR GENERATOR SETS

Qu	KW	Make	Speed	DC	AC
3	60	E.M.	1200	125	220 v. Syn.
1	75	G.E.	1200	125	2300/4160 Syn.
2	100	West.	1200	250	2300/415Y Syn.
1	175	West.	1200	125	4150 Syn.
1	300	G.E.	1200	250	2300/4160Y S.R.
1	300	G.E.	1200	250	440 Sync.
1	1000	West.	720	600	2300/4160Y

ENGINE GENERATOR SETS

1—Hercules Gas EXE 62.5 KVA Westghe 3/60/480—1200

1—Wisconsin Gas (Air) PE-99 7.5 KVA Master 1 or 3/120—2200 r.p.m. NEW

SLIP RING MOTORS

Qu	HP	Make	Speed	Type	Volts
2	40	West.	690	CW	220/440
1	60	G.E.	1800	MT	220
1	75	G.E.	600	TM	440
2	100	West.	1800	T.E.F.C. B.B.	220
1	150	G.E. Triclad	1175	M	220/440
3	150	Allis Ch.	1800	AY RW	2300
1	200	West.	514	CW	440
1	250	West.	600	CW	440
1	350	West.	1800	CW	2300
1	500	G.E.	450	MT	2200
1	500	G.E.	1200	M569Z	2300/4160Y

EXPLOSION PROOF

2—200 HP Continental NP216Z—BB—1800 r.p.m. 3/60/220/440

1—30 HP Louis-Allis 444—BB—1200 r.p.m. 3/60/220/440

D.C. MOTORS—230 VOLTS

Qu	HP	Make	Speed	Type
1	75	Cr. Wh.	860	WP 53 H
7	75	Star	1200	SB 60 L B B
1	350	G.E.	1200	Pedestal

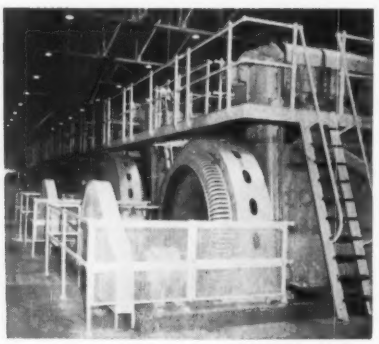
FOR POWER

J.L. HEMPHILL & CO.

1603 54th STREET, NORTH BERGEN, N.J.

PHONE NEW YORK—LONGACRE 5-3227

PHONE NEW JERSEY—UNION 3-2600



13,750 KVA POWER PLANT. STILL INSTALLED. Will be sold as complete unit or piece by piece. Consists of (11) 1250 KVA Rathbun-Jones Natural Gas Generator Sets. **ENGINES**—1430 HP, 8 Cylinder, 4 Cycle, 300 RPM, direct connected to **GENERATORS**—1250 KVA, .8 PF, 3/60/2400-4160. Complete with Switchgear. Can be seen in operation on foundations. **PRINTS** and Photos available. Write **HEAT & POWER CO., INC., POWER EQUIPMENT DIVISION,** 60 E. 42nd St., New York 17, N. Y.

AIRCRAFT FOR SALE

PBY Amphibian Aircraft . . . Surplus to Canadian Exploration Company's use • extra large cargo doors and floor • executive passenger compartment, emergency Rocket Power • galley facilities • survey turret in nose. Aircraft completely outfitted for all-weather flight and 2 crew operation. In excellent condition • available for immediate sale or long term lease.

Royal Gull Amphibian . . . The world's most economical and versatile "Executive" amphibian • used exclusively as a demonstrator and executive charter ship • only 400 hours since manufacture • new custom exterior paint and customized interior. Available for immediate sale or lease attractive terms.

DeHavilland Beaver . . . Top condition throughout • used solely as an ambulance ship since new • zero time—Pratt & Whitney overhauled engine, new C. of A. Excellent radio and instrumentation • complete with Federal wheel/skiis and Edo floats. Your inquiries are invited.

Bell 47-H Executive Helicopter . . . Maintained in new condition throughout for the exclusive use of a high ranking government official • 250 hours total time • Janitrol heater • floats • skids • skiis • all modifications up • payload for 3 persons and 2:20 hours range • exceptional discount.

TIMMINS AVIATION LIMITED
MONTREAL AIRPORT, CANADA

AVAILABLE AT ONCE

3750 K.V.A. WESTINGHOUSE
CONDENSING TURBINE-GENERATOR

With a 42000#/Hour Late Riley Boiler Turbine: 3000 KW 400 PSI 750° FTT 3600 RPM Generator: 3000 KW 0.8 PF 3750 KVA 3600 RPM 3/60/2400/4150 V. Condenser: 4500 sq. ft. 2 pass 30000#/hr 5500 GPM at 85°F with all pumps, auxiliaries, etc. This equipment installed new in 1949 and until recently utilized in modern power plant in Flora, Illinois. Still on original foundation and available for inspection.

ALSO OFFERED—1—625 KW Westinghouse 185# PSI 3/60/2400 V., 3600 RPM. Direct Connected Exciter, 2000 sq. ft. Condenser, auxiliaries. Priced for quick sale.

C. B. EQUIPMENT CO.
1800 Locust St., St. Louis 3, Mo.
PH. CHestnut 1-1101

FOR SALE

BOILERS

1—75,000# B & W Stirling 250 psi

1—90,000# B & W Stirling 450 psi

2—B & W Stirling 329 HP, 160 psi

2—B & W Sectional header 750 HP, 250 psi

2—B & W Sectional header 60,000#s 450 psi

2—Union Iron Works 40,000#, 250 psi

1—Union Iron Works 120,000#, 250 osi

1—Erie City Box Header 30,000# 250 psi

1—Riley 40,000#, 280 psi

1—Vogt 40,000#, 350 psi

TURBO-GENERATORS

1—West., condensing, 3600 rpm, 3000 kw.

1—West., condensing, 3600 rpm, 1500 kw.

1—West., condensing, 3600 rpm, 3125 kva.

1—Gen. Elect. condensing, 3600 rpm, 1500 kw.

1—Gen. Elect. condensing, 3600 rpm, 3600 kva.

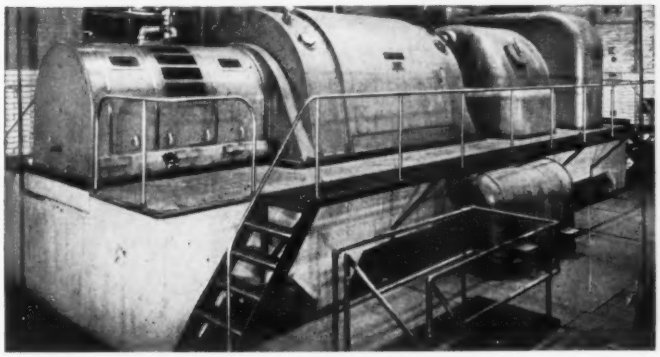
1—Elliot, condensing, 3600 rpm, 1875 kva.

MIDWEST BOILER & TURBINE CO.
616 Vaughn Avenue Dyersburg, Tenn.
ATwater 5-4396

IMMEDIATELY AVAILABLE

650 LB. PRESSURE, 750° FTT TURBINE-GENERATORS

10,000 KW, 70% P.F., 14,286 KVA below:



This 10,000 KW is a Westinghouse, Condensing 650 Lb. PSIG, 750° FTT Turbine. It is equipped with Surface Condenser, Switchboard, with all auxiliaries, direct connected Exciter (closed type). Generator is 3/60/12000 V., 3600 RPM at 70% P.F., 14,286 KVA. Installed new in 1947.

CHARLES WEAVER, INC.

19701 James Couzens Hwy. Tel: BRoadway 3-1900 Detroit 35, Michigan

---

2 OIL BURNING BABCOCK & WILCOX WATER TUBE BOILERS

Designed for T2-SE-A2

Now being removed at Philadelphia, Pa., from the S.S. Mission San Francisco.

Complete with deaerating feed heaters, Coffin feed pumps, oil pumps, 1st, 2nd & 3rd stage heaters. Evaporation: normal 43,000 lbs.; max. 60,000 lbs. Designed boiler pressure 700 P.S.I. Final steam temp at superheater outlet 825° normal. Superheat safety valve setting 624 P.S.I. Boiler heating surface including water wall 6350 sq. ft. Total water heating surface 8030 sq. ft. Economizer heating surface 1680 sq. ft. Operating pressure superheater outlet 600 P.S.I. Furnace volume 573 cu ft. Evaporation rate from and at 212 F lbs/hr/sq ft of total boiler heating surface: Normal 8.33—max. 11.74. Water wall heating surface 118 sq ft. Feed water temp 240 F. Immediate delivery. Presently on barge at Philadelphia. Dimensions: 19'8" high over drum flange: 14' 9-5/16" over casing plate; 16' wide over drum.

THE BOSTON METALS CO.
313 E. BALTIMORE STREET
BALTIMORE 2, MD. ELgin 5-5050

BOILERS

HI-PRESSURE

Complete stock from 10-2,000 h.p.
Nation's largest inventory, New & Used

WABASH POWER EQUIPMENT CO.
9750 Skokie Blvd., Chicago (Skokie) Ill. OR 3-8118

GUARANTEED "REBUILT" POWER EQUIPMENT

SQUIRREL CAGE MOTORS

3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
1750	*G.E.	K	3600
1750	*G.E.	K	1800
1250	*Al.-Ch.	ANX	3600
600	West.	CS	720
600	*G.E.	K-6345S	1200
500	*G.E.	K-6345S	1200
500	*G.E.	I-13-E	900
350	*G.E.	KT-559-A	1800
300	*G.E.	K6344	1200
250	*W (TE)	CS-81205	1800
250	*G.E.	KT-599-S	1800
250	*West.	CS-875-S	1800
250	Brook	RS28	1200
200	*G.E.	FT-540	3600
200	West.	I-K-13B	1800
200	Brook	CSP-581-S	1800
200	*West.	RS-27	1200
200	G.E.	CS-930-A	900
200	*Al-Ch	KT-564-S	720
200	*West.	AN-37-G	720
200	Al-Ch	CS-1010	600
200	*G.E.	ARW-631	600
150	Cr-Wh	SC-140	3600

SQUIRREL CAGE MOTORS

3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
150	Al-Ch	AN-30-F	1200
150	West.	CSP-5815	1200
150	G.E.	I-K-15A	900
150	*West.	CS	600
125	Al-Ch	AR-226	1800
125	G.E.	5-Q	1200
125	Cr-Wh	K-558	900
100	W (TE)	CS-507-S	3600
100	G.E.	FT-542-Z	1800
100	Al-Ch (TE)	ARZ-826	1200
100	Al-Ch	AW-23-D	1200

SLIP RING MOTORS

3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
2500	*G.E.	MT (Mill Type)	257
1100	*G.E.	MT	720
1000	*G.E.	M-575-S	1200

SLIP RING MOTORS

3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
1000	*West.	CW	450
600	*G.E.	M-6345-S	1800
500	G.E.	M-6345	1200
400	*G.E.	MTP-565	1200
350	*Al-Ch	ARYW	1800
300	Cr-Wh	SR70-R	1800
250	Al-Ch	ARY-626	1800
250	*G.E.	I-M-17A	720
200	G.E.	I-M-16	600
200	*West.	CW1950A	514
150	Cr-Wh	SR-50R	1800
150	G.E.	I-M-15A	600
125	G.E.	I-M-15A	600
100	G.E.	I-E-13A	1800
100	G.E.	MT558	720
100	G.E.	I-M-15A	425
75	West.	CW-770	1200
75	G.E.	MT-347	1200
75	G.E.	MT-356	900
75	G.E.	MT-352	720
75	G.E.	I-M-10	600
60	G.E.	MT-356	1200
60	*West.	CW-762C	900
50	*G.E.	MT-536	1200

WRITE FOR CURRENT STOCK LIST

CHICAGO Electric Co.

ALL TYPES OF EQUIPMENT IN STOCK

1320 W. CERMAK RD. • CHICAGO 8, ILL. • PHONE: CANAL 6-2900

DIESEL GENERATORS

435 KW General Motors Quad portable diesel generator. 650 HP. Skid mounted, radiator cooled. Westinghouse 3/60/2300 generator, complete, used 60 days.

450 HP Fairbanks Morse Model 32E14, 375 KVA. 3/60/2400 volts. With complete auxiliaries. New in 1944.

Condition is first class. Priced attractively.

Other sizes available. Also Construction and Railway equipment.

WHISLER EQUIPMENT CO.
611 Olive St. St. Louis 1, Mo.
CHestnut 1-4474

TRANSFORMERS

1—300 KVA, 3/60/4160-240 Wagner, ITE type HPE Unit Substation, Outdoor.
2—250 KVA, 1/60/2400-240/480 Moloney OISC, type YC, with taps
1—225 KVA 3/60/440-208Y/120, Moloney Dry
1—250 KVA, 4—150 KVA, and 2—100 KVA 1/60/4160-240/120 Whse. Inerteen with taps
1—200 KVA 3/60/4160-240 Wagner, ITE type RPB Unit Substation, Outdoor.
3—15 KVA, 1/60/240-480/120-240 Sorgel Dry

CASH

For Surplus Electrical Equipment

BENSON-WILIMZIG, INC.
1708 North 8th St., St. Louis 6, Mo.
Phone GArfield 1-4290

ELECTRICAL POWER EQUIPMENT

A. C. MOTORS—3 Ph. 60 Cy.

SLIP RING

Qu.	HP	Make	Type	Volts	Speed
1	1750	G.E.	M-579BS	4800/2400	1800
1	1500	G.E.	MT	6900	1187
1	1100	F.M. RB	SF306S	4800/2400	1800
1	800	Whse.	CW	550	1776
1	700	AL.-Ch.	D.P.	2300	500
1	600	Whse.	CW-432D-15	440	1778
1	500	Whse	CW	550	350
1	350	Cr. Wh.	SIZE-718R	208/406	1763
1	350	G.E.	IM-17A	440/2200	720
1	350	Whse.	CW-1039C C-15	440	720
1	250	G.E.	MT-424Y	4000	257
1	250	Cr. Wh.	SIZE-290	2300	350
1	250	A.C.		550	600
1	200	G.E.	IM	2200	580
2	200	G.E.	IM	2200	425
2	200	Whse.	CW-800	2300	1775

SQUIRREL CAGE

1	800	G.E.	KT-573	2200	1180
1	500	G.E.	FT-559AY	2300	3600
1	350	Whse.	CS-1115	2300	900
4	500	Whse.	CS-1216	2200	500
2	450	Whse.	CS-1420	2300/4150	354
2	100	Whse.	CS-7151-610H		
1	300	Elliott		6600/4000	3565
1	125	Allis Ch.	BA-684Z	440	1770
1	400	G.E.	AW-23F8	440	1170
2	200	G.E.	IK	2200	500
2	200/150	Whse.	KT-557	440	1800
1	200	Whse.	CS-963H	2300	1175/878
1	150	Whse.	CS-1002	2300/400	450
1	150	G.E.	CS	440	580
			IK-15A	2300	860

SYNCHRONOUS

1	7000	G.E.	ATI	2240/6600	600
1	4350	C.W.	3501-SL	13800/6900	514
1	3500	G.E.	TS-6487P	4600/2300/4000	360
2	1750	G.E.	ATI	2300	3600
1	1750	G.E.	TS	2300	900

M-G SETS—3 PH. 60 CY.

Qu.	K.W.	Make	RPM	DC Volts	AC Volts
2	2100/1750	G.E.	514	250/350	2300/4600
1	2000	G.E.	514	660	2300/4600
1	1500	G.E.	720	600	6600/13200
1	1500	G.E.	600	600	2300/4150
1	1000	G.E.	900	260	6600
2	1000	G.E.	720	600	6600/13200
1	750	G.E.	720	275	6600/13200
1	500	Whse.	900	125/250	440
1	350	G.E.	900	125	440/2300/4160
2	300	G.E.	1200	250	2300
1	250	Whse.	1200	275	2300
1	200	El Mby	1200	250	2300/4600
1	300	Whse.	1200	600	2300
1	200	Whse.		550	2300
1	200	G.E.	1200	250	550/3300
1	200	Cr. Wh.	1200	250	440
1	150	Whse.	1200	275	2300
1	100	G.E.	1200	250	4160/2400

TURBO GENERATORS

Qu.	KW	Make	Desc.
1	7500	Whse.	650# condensing, 125# auto extraction, 6900
1	5000	G.E.	400# surface condenser 2400/4150 volts.
1	4000	G.E.	400# surface condenser 2400/4150 volts.

TRANSFORMERS

Qu.	KVA	Make	Type	PH.	Voltages
3	3333	Whse.	OISC	1	13800x2300
1	1500	G.E.	PYRANOL	3 auto	4000/4200/4400
2	1000	G.E.	OISC	1	13800x460
2	750	G.E.	FUR	1	4800x35/55
3	500	KUHL	OISC	1	13600x6000
1	225	Marcus	Air	3 auto	208/220
3	100	G.E.	OISC	1	22900x2400/4160Y
3	100	Whse.	OISC	1	4600x460/230/115

FREQUENCY CHANGER SETS

Qu.	KW	Make	Freq.	Voltage
3	6750	G.E.	60/25/60	13200/13200
1	5000	G.E.	60/50/60	11000/6600
2	2500	G.E.	25 cy/62.5	2300/2300
1	500	Al. Ch.	25/60	11000/2300
1	200	G.E.	60/3000	440/880

COMBINATION MILL DRIVES—
D.C. MOTORS WITH M.G. SETS & CONTROLS
PACKAGE DRIVES IN STOCK

1—2250 HP Elliott 300 V. 200/300 RPM DC Motor with 2400 KW GE MG Set. 300 V. DC 2300/4600 V, 450 RPM 3 ph. 60 cy.
1—1375 H.P. G.E., MCF, 415 V. 1200 RPM D.C. motor with 1100 KW G.E. MG Set 415 V DC, 2300/4000 V. 720 RPM 3 ph. 60 cycle.
1—1300 HP G.E. MPC, 600 V, D.C. Motor, 450 RPM, and 1000 KW, G.E. M-G Set, 600 volt DC with 1400 KP, .8 PF, Synch. Motor 13200/6600 volt, 3 ph. 60 cy.

RE-NU-BILT BY

BELYEA COMPANY INC.
43 Howell St., Jersey City 6, N. J.
Tel: OLDFIELD 3-3334

37 Years Dependable Service

SLIP RING MOTORS 3-Ph., 60 Cy.

H.P.	Volts	Make	Speed
500	4000/2300	G.E.	600
450	440	Whse.	514
400(2)	2300	G.E.	900
400	4000/2300	Whse.	720
300	4000/2300	G.E.	720
300	2300	G.E.	900
300	440	G.E. (hoist)	600
300	440	Whse.	3600
225	4000/2300	G.E. (hoist)	600
200	2300	G.E.	600
200	2200/440	G.E.	720
150	220/440	Whse.	720
125	2200	G.E.	600

AC GENERATORS or SYN. MOTORS, 60 Cy.

H.P.	Volts	Make	Type	R.P.M.
400	2200/440	G.E.	ATI	720
300	2300/400	G.E.	TS	720
300	2200/440	G.E.	TS	1200
200	2300/440	Whse.	G	1200
150	440/220	Whse.	G	1200
125	440/220	Whse.	HR	400

SQUIRREL CAGE MOTORS

500	2200/4000	Elliott	SC	1800
400	2300	G.E.	FT	3600
350	2300/440	G.E.	IE-K	1200
300(2)	2200	G.E.	FT	3600
300	2300/4000	L. Allis	FS	1800
200	440/220	G.E.	KT	1800
200	2200	G.E.	KT	1800
200	2200	Cont.	TEFC	3600
200	440/220	G.E.	KT	720
200	2200/440	G.E.	IE-K	1200
150	440	Whse.	X-prf.	3600
150	2200	Al. Chal.	KT	720
150	440/220	G.E.	TEFC	720
150	2200/440	G.E.	AR	1800
150	2200/440		KT	600
150	2200/440	G.E.	FT	1200
125(2)	2200/440	Whse.	X-proof	720
125	2200/440	G.E.	K	600
100(2)	4000/2300	L. Allis	OX	1200
75(2)	440	Wagner	TEFC	1800

CIRCUIT BREAKERS, 3 Pole

1—600 Amp., Whse., 600 V., Air, New
4—1600 Amp., DA-50, Whse., 600 V., Air
6— 600 Amp., R. Smith, 7.5 KV, Sol. oper.
6— 600 Amp., FK-155, G.E., 15 KV, Sol. oper.
1— 400 Amp., R. Smith, 7.5 KV, outdoor, New

D. C. MOTORS

H.P.	Volts	Make	Type	Speed
200	230	Cr. Wh.	CMC	1200
150	230	El. Dyn.	B/brg.	600
125	230	G.E.	CD	350

MOTOR GENERATOR SETS

KW	Make	Input V., AC	Motor Type	Output V., DC
250	Whse.	440	Syn.	250
125	G.E.	440/220	Sq. Ca.	125
125	G.E.	440	Sq. Ca.	250/125
100	G.E.	2200/440	Syn.	250
75	Cr. Wh.	440/220	Sq. Ca.	240/120
65	G.E.	2200/440	Sq.Ca.	250

TRANSFORMERS 60 Cy.

1—500 kva, Al. Ch., 2400/4160Y—600 volts, 3 ph.
3—500 kva, G.E., 13,800—300 V.
3—333 kva, G.E., 13,800—2300 V.
3—333 kva, G.E., 2400-240/480 V.
2—300 kva, G.E., 4150—240 V., 3 ph., Pyr.
1—200 kva, Al. Ch. 6900—220 V., 3 ph.
3—200 kva, Whse., 4600/2300—230/115 V.
1—200 kva, G.E., 2400—120/240 V., Pyr.
3—200 kva, Mol. 13,800—2300 V.
3—150 kva, Al. Ch. 2400—220 V.
3—150 kva, Al. Ch. 440-220 V., dry New
3—150 kva, G.E. 13,200—2300 V.
3—100 kva, Whse. 4800/2400-240/480 V., Dry
3—100 kva, G.E., 2400—120/240 V., Pyr.

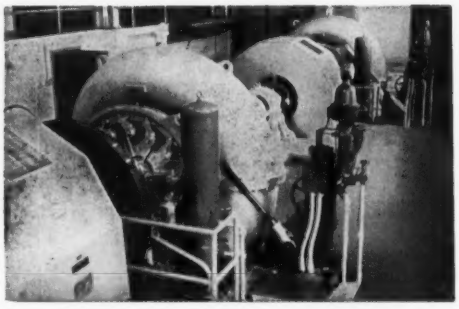
GASOLINE—ENGINE GENERATOR SETS

1—94 kva 1200 R 220 V 3 ph. Buda, 6 cyl. SLIGHTLY USED
2—25 kva 900 R 220 V 3 ph. conn. LeRoi, 6 cyl. NEW

only partial listing

STEPHEN HALL & CO.
HARRY J. RICE, Pres.
625 ADAMS ST., HOBOKEN 2, N. J.

TWO 1,500 KW HYDRO ELECTRIC PLANTS



2000 HP Pelton type Turbines, 160 ft. head, 600 RPM, 4160 Volt, 3 phase, 60 Cycles, .8 PF, Direct connected excitors, complete modern cubicle. Three 1250 KVA Transformers 66,000-38,150-4160 Volt, and taps. Plants were in service less than four years and are in new condition. Immediate delivery.

GENERAL MACHINERY LIMITED
GRANVILLE ISLAND **VANCOUVER, B. C.**

1902 COMPRESSORS 1958
WORLD'S BEST REBUILTS

100 CFM 125 psi 6x7 Ing.
138 CFM 100 psi 7x7 Ing. ES-1
140 CFM 3500 psi 12¼x10 Norwalk—unused.
191 CFM 350 psi 9-4x9 Ing. ES-2
238 CFM 100 psi 9x9 Ing. ES
298 CFM 500 psi 10-4¼x10 Ing. or Worth.
465 CFM 100 psi 12x11 Penn. or Ing.
502 CFM 125 psi 12x13 Worth. HB.
585 CFM 100 psi 15-9¼x12 Ing. XRE 3-60-4160
590 CFM 100 psi 13½-8x8 Penn DE2 3-60-220
678 CFM 100 psi 15-9¼x12 Ing. XRB—Worth.
686 CFM 100 psi 14x13 Worth. HB.
870 CFM 125 psi 17-10½x12 Ing. XRE 3-60-220
1007 CFM 100 psi 19-11x12 Chic. OCB
1410 CFM 35 psi 20x13 Worth. HB—unused.
1721 CFM 125 psi 23-13x16 Chic. OCE 3-60-2300
2832 CFM Vacuum 81x13 Ing. St. or Elec.
PORTABLES—55-60 CFM Rotary or Reciprocating

AMERICAN AIR COMPRESSOR CORP.
Dell Ave. & 47th St. North Bergen, N. J.
UNion 5-4848

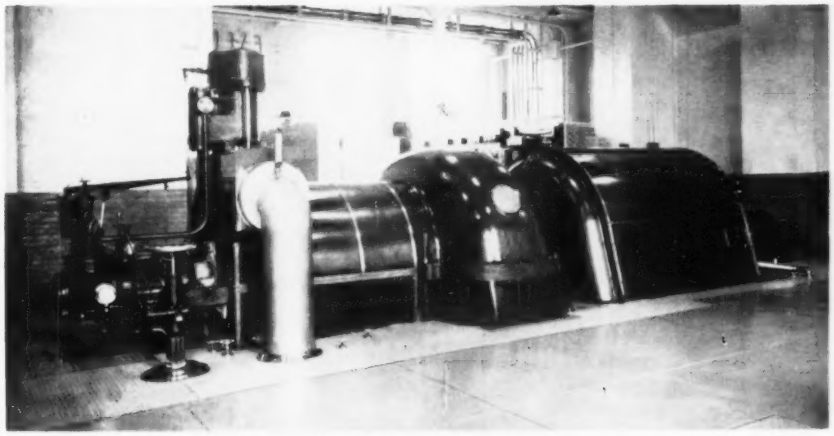
AUTOMATIC and MANUAL
GAS Or DIESEL GENERATOR UNITS
Complete Switchboard Design or Construction
USED & REBUILT EQUIPMENT
UNIVERSAL POWER ENGINEERING CO.
217 Colden St. Jersey City, N. J.
Phone: DElaware 2-8300

SAVE 50% or more . . .
On Transformers & Regulators!
NEW and USED surplus transformers and regulators available at considerable savings, 25 KVA to 10,000 KVA. Write for prices, giving specifications.

INDUSTRIAL ELECTRIC CO.
Box 661 Moultrie, Ga.

BARGAIN OFFERING

6250 KVA—5000 KW, 80% P.F. TURBINE GENERATOR
400 PSIG, 700°FTT 3 PHASE 60 CYCLE 2400/4160 VOLTS



(Actual Photograph Above)

5000 KW, 3600 RPM General Electric condensing turbine generator unit, complete installation with surface condenser, auxiliaries and direct connected exciter. Excellent condition.

UTILITIES MACHINERY CORPORATION
1965 EAST SIXTH STREET TELEPHONES: CH 1-0210 & CH 1-4070 CLEVELAND 14, OHIO

HIGH PRESSURE STEAM BOILERS

***Government Surplus* SAVE OVER 75%**

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121,650 Lbs.

1 Foster Wheeler
Express Type, 3-drum, with integral superheater separately fired.
Includes boiler, superheater, economizer, 7 fuel oil burners, soot blowers.
Pressure 634 psi, temp 850° F.
Furnace Vol: boiler 310 cu. ft., superh. 247 cu. ft.

60,000 Lbs.

10 Babcock Wilcox
3 Foster Wheeler
"D" Type, 2-drum, with integral superheater fired between boiler tube bank.
Includes boiler, superheater, economizer, 3 fuel oil burners, soot blowers.
Pressure 435 psi, temp 750°F.
Furnace Vol: 330 Cu. Ft.

We own and stock these boilers. Inspection Invited at Utica, N.Y. Subject to prior sales.

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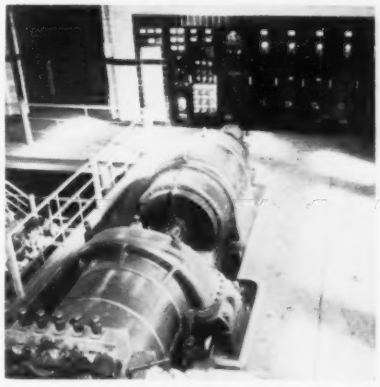

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400	West. S.B. Open	CS	900
350	A.C. S.S. Drip	ARWW-626	3600
300	G.E. S.B. Open	IK	1800
300	A.C. S.B. Open	AR-630	1800
300	F.M. B.B. Open	H	1800
300	G.E. S.B. Open	IK	900
300	G.E. S.B. Open	IK	720
300	West. S.B. Open	CS-1002	600
250	G.E. TEBB, 2300 V	K	1800
250	G.E. S.B. Open	KT	1800
250	F.M. B.B. Open	H	1800
250	G.E. S.B. Open 2200 V	IK-16	1200
250	G.E. S.B. Open	IK	1200
250	G.E. S.B. Open	IK	900
250	G.E. S.B. Open	IK	720
200	G.E. S.B. Drip	K-6326	3600
200	G.E. T.E.F.C.B.B.	K-6329	3600
200	F.M. B.B. Open	H-207	1800
200	G.E. TEBB	K	1800
200	Cont. T.E.F.C. B.B.		1800
200	Cont. T.E.F.C. B.B.	NP-686C	1800
200	G.E. S.B. Open	IK-15	1200
200	G.E. S.B. Open	IK-15S	1200
200	G.E. S.B. Open 2200 V	IK	1200
200	G.E. S.B. Open	IK	900
200	English B.B. Open	P-125.5	720
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150	G.E. TEFCB XP	K	3600
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Design steam pressure 140 psig
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Condensing operation at 28 inch vacuum

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625 KVA, 2300 volts, 157 amps. maximum
Phase 3, frequency 60, r.p.m. 3600

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Allis-Chalmers directly connected, Serial No. 117582
volts no load 125, volts full load 125
amps. 56, r.p.m. 3600

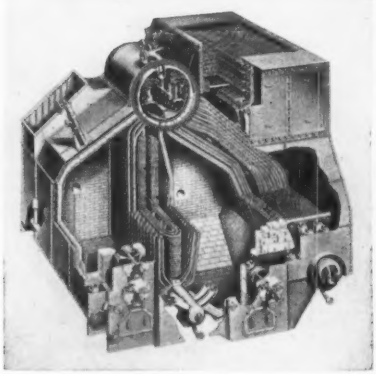
GENERAL

Net weight of turbine in pounds—10,500
Net weight of generator in pounds—10,366
Net weight of complete unit in pounds—29,700
Weight of heaviest part handled during erection in pounds—17,900
Weight of heaviest part handled after erection in pounds—2,500
Diameter steam inlet at turbine—6 inches
Diameter turbine exhaust nozzle—20 inches
Approximate overall length—18 ft. 5 in.
Approximate overall width—4 ft. 3 in.
Approximate height of highest point of unit above floor line—5 ft. 7 in.

CONDENSER

C. H. Wheeler standard surface condenser with horizontal cast iron shell. Contains 1000 sq. ft. of condensing surface consisting of ¾ inch O.D. No. 18 B.W.G., Muntz metal tubes 9 ft. long. Tubes secured in Muntz metal tube sheets with threaded Muntz metal ferrules and metallic packing. Repairs required.

Above may be seen by contacting Salvage Dept. Room 100 Administration Bldg., MICHIGAN STATE UNIVERSITY, E. Lansing, Michigan. Telephone: EDgewood 2-1511, Extension 2133.



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B&W, Combustion Engineering, Foster Wheeler. Steel encased. 2 Drum Water Tube with Water Walls, Superheater, Economizer, Soot Blowers, Oil Burners. Complete.

# Steam/hr	PSIG	FTT
153,600	565	850
122,500	565	850
60,000	435	750
44,500	450	735
35,000	285	577

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1—Pritchard Cooling Tower—New 1951, Model 2418BQR111, Two Cells, 2300 GPM.

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1 New unit by C. H. Wheeler. Test pressure shell 30 lbs; water box 30 lbs.—single pass. Turbine steam exhaust inlet 6' 3¾" x 10' 2". Overall width 12' 2¼"; overall length 14' 10¾"; overall height 5'7". Water inlet 36" x 30" outlet. Monel heads and water boxes. Cupro-Nickel tubes. Built for U.S. Navy of very best materials.

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11000 SQ. FT. C. H. Wheeler, Single Pass, Steel Shell, Cupro-Nickel Tubes and Tube Sheets, Monel Water Boxes.

3800 SQ. FT. Foster Wheeler, Single Pass, Steel Shell, Cupro-Nickel Tubes and Tube Sheets, Monel Water Boxes.

3500 SQ. FT. Alco, 2 Pass, Admiralty Brass Tubes, Naval Brass Tube Sheets, Steel Shell, Cast Iron Water Boxes.

2200 SQ. FT. Alco, 2 Pass, Steel Shell, Cupro-Nickel Tubes and Tube Sheets, Gun Metal Water Boxes.

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1350 SQ. FT. Alco, 2 Pass, Steel Shell, Cupro-Nickel Tubes and Tube Sheets, Bronze Water Boxes.

1250 SQ. FT. Westinghouse, 2 Pass, Steel Shell, Cupro-Nickel Tubes and Tube Sheets, Bronze Water Boxes.

1050 SQ. FT. New York Shipbuilding, 2 Pass, Steel Shell, Cupro-Nickel Tubes and Tube Sheets, Bronze Water Boxes.

725 SQ. FT. C. H. Wheeler, 2 Pass, Steel Shell, Cupro-Nickel Tubes and Tube Sheets, Bronze Water Boxes.

580 SQ. FT. Foster Wheeler, 2 Pass, Steel Shell, Cupro-Nickel Tubes and Tube Sheets, Bronze Water Boxes.

436 SQ. FT. C. H. Wheeler, 2 Pass, Steel Shell, Cupro-Nickel Tubes and Tube Sheets, Bronze Water Boxes.

400 SQ. FT. Allis Chalmers, 2 Pass, Steel Shell, Brass Tubes and Tube Sheets, Bronze Water Boxes.

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GENERAL ELECTRIC 6-section cubicle, with (5) type FKR-225-150, 3-P.S.T., 600 amps., 15-KV Mag. Draw-out O.C.B.'s, complete with metering equipment. 150-M.V.A.

GENERAL ELECTRIC 7-section, OUTDOOR Cubicle with (5) AM-5-100-4Z, 1200 amps., 5-KV mag. Draw-out Air Breakers, with all metering, batteries, charger, etc., 10-M.V.A. (1) 400 AMPS. 73-KV WHSE. OUTDOOR 3-pole Mag. O.C.B. type G-11-500-M.V.A.

SAVE $30,000. ON THIS PACKAGE

(1) 600 AMPS. G.T. type F.L.O. 14.4-4-250, 3-pole Mag. OUTDOOR O.C.B., 250-M.V.A.

(1) 600 AMPS. AL. CH. type FZO-50-34X, OUTDOOR 3-pole Mag. O.C.B. 34.5-KV, 250-M.V.A.

(1) WHSE. OUTDOOR 3-section cubicle with (2) 600 AMPS., 3-pole Mag. O.C.B.'s type F-100, 15-KV, 100-M.V.A. with complete metering.

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1—250 HP AL. CH. 3/60/2300V/1760 RPM ARW
1—350 HP Elec. Dyn. 3/60/2300V/1765 RPM BB Fr 253
2—350 HP GE Syn 3/60/2300V/900 RPM TS 7653
1—1250 HP F.M. Syn. 3/60/13,200V/720 RPM w/Dir. Exc
23—1500 HP West. DC 525V (Unused)
3—300 KW GE DC 260V 1200 RPM 1 Brg
1—750 KW West. AC Gen. 3/60/220-440V/600 RPM w/Top Belted Exciter
4—1200 KW AL. CH. 2 Brg DC 525V 720 RPM Gen.

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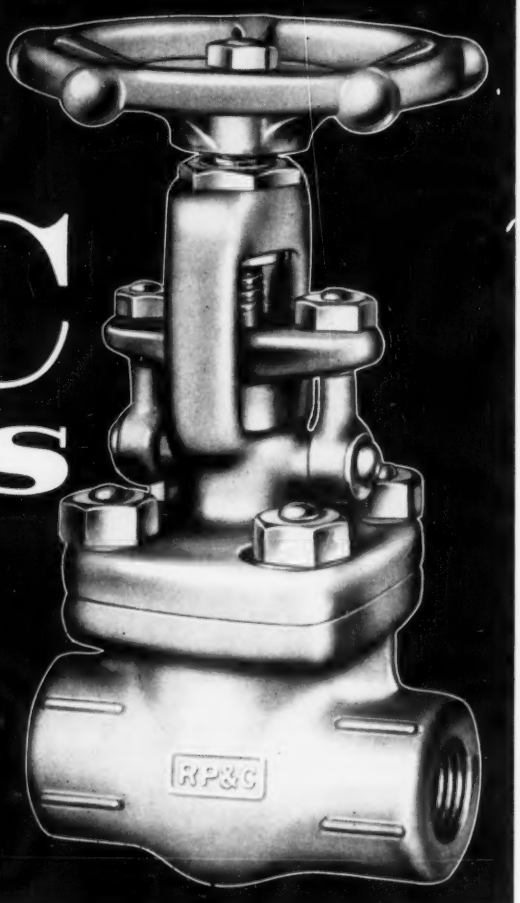

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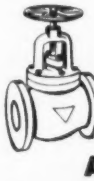
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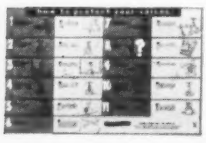

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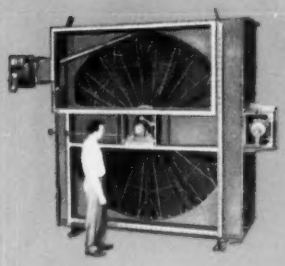

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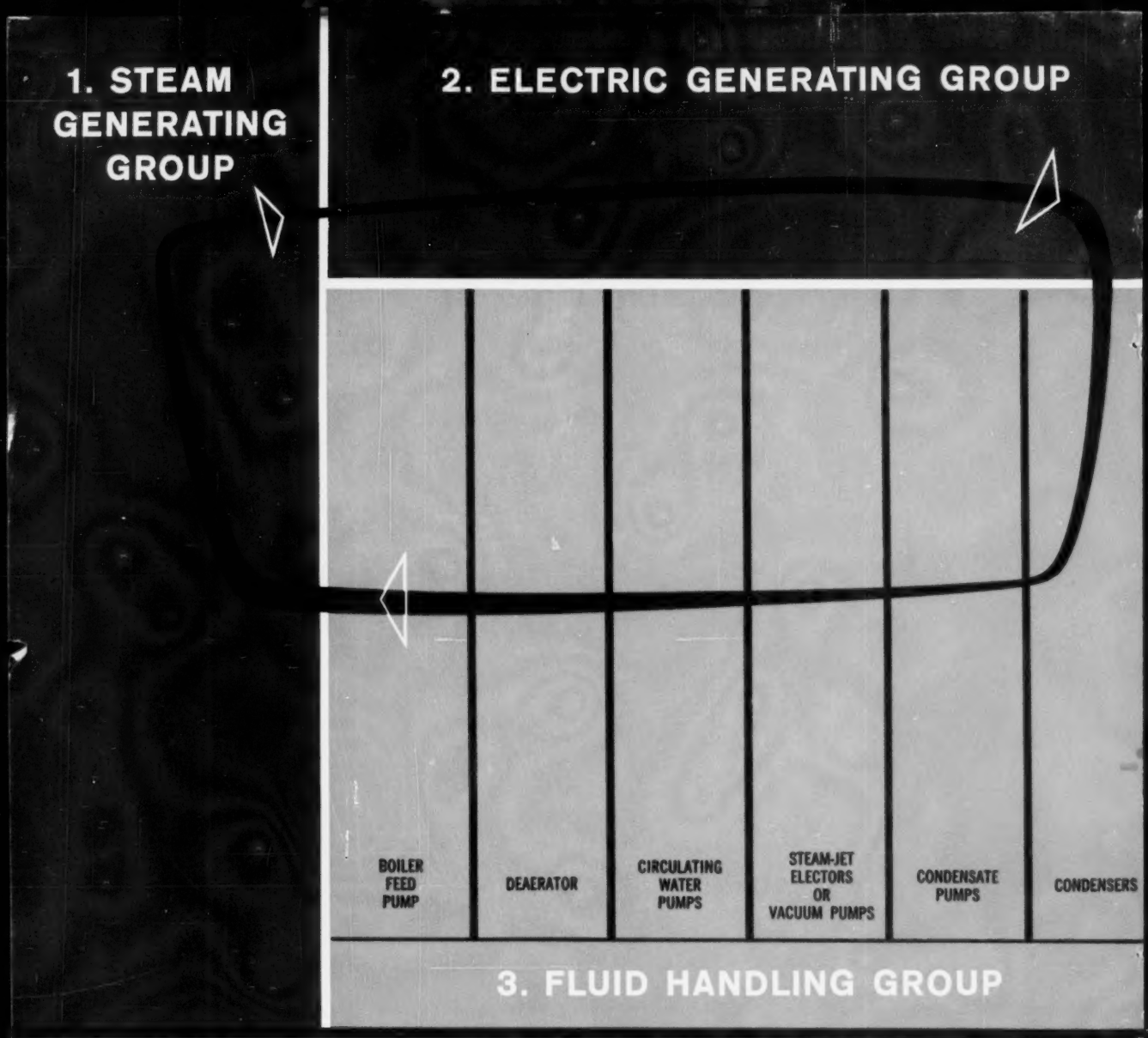

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